Schlumberger

Marine Mammal Impact Assessment

Schlumberger 3D Seismic Survey

Pegasus Basin

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Executive Summary

Schlumberger New Zealand (Schlumberger) is proposing to acquire a three dimensional (3D) marine seismic survey in the East Coast and Pegasus Basins. The Operational Area extends from Cape Kidnappers (Hawke's Bay) in the north to Conway Flat (North Canterbury) in the south. Although the Operational Area does not adjoin the coast, it does include a small section of the territorial sea in the vicinity of Castlepoint (Wairarapa). This survey is referred to as the 'Pegasus Basin Seismic Survey'. Schlumberger are planning to undertake this seismic survey between November 2016 and June 2017, and the survey will have an approximate duration of six months.

The *M/V Amazon Warrior* will be used to undertake the Pegasus Basin Seismic Survey and will tow a 5,085 in^3 acoustic source that will be activated every eight seconds. The seismic vessel will also tow 14 streamers of approximately 8 km in length. Each streamer will be separated by 100 m; hence the span of towed gear is approximately 1,300 m. During the survey, the *M/V Amazon Warrior* will be travelling between four and five knots.

This Marine Mammal Impact Assessment (MMIA) is a pre-requisite to seismic operations in New Zealand's Exclusive Economic Zone (EEZ) which, under the EEZ (Environmental Effects) Act 2012 and the associated Permitted Activities Regulations stipulate mandatory compliance with the Department of Conservation's 2013 *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the 'Code of Conduct'). As well as compliance with the Code of Conduct, Schlumberger will operate in accordance with relevant NZ legislation, international conventions and their internal environmental standards.

This MMIA sets out to describe the proposed seismic operations, to provide a description of the baseline environment, to identify the actual and potential effects of the operations on the environment and to specify the measures that Schlumberger intends to take to avoid, remedy, or mitigate any potential adverse effects. An assessment of the significance of any effects is also provided through an Environmental Risk Assessment process. The MMIA not only includes a discussion on the potential effects of seismic operations on the biological environment, but also on the social, cultural and commercial environments relevant to the Operational Area.

A significant part of the development of this MMIA was engagement with stakeholders through the provision of information sheets and meetings. Information collected during this engagement process was used to populate the MMIA and to refine the survey design where possible.

A number of marine mammal species are likely to be present in the Operational Area; southern right whales, minke whales; Bryde's whales, sperm whales, pygmy sperm whales, beaked whales, common dolphins, long-finned pilot whales, dusky dolphins, killer whales, false killer whales, bottlenose dolphins, New Zealand fur seals and southern elephant seals. Of these species, southern right whales, Bryde's whales, killer whales, bottlenose dolphins and southern elephant seals are considered as threatened under the New Zealand Threat Classification System.

Acoustic disturbance from seismic surveys is considered to be the most significant potential effect from the Pegasus Basin Seismic Survey, and compliance with the Code of Conduct is the primary mitigation measure proposed. The key mitigations outlined in the Code of Conduct are 1) the presence of marine mammal observers whose role it is to visually and acoustically detect marine mammals, 2) the use of delayed starts if marine mammals are detected in close proximity to the acoustic source before operations commence, 3) the use of 'soft starts' to ensure that any undetected marine mammals have an opportunity to leave the vicinity before full operational power is reached, and 4) shut downs of the acoustic source if marine mammals enter the defined mitigation zones.

Executive Summary

Sound transmission loss modelling was conducted as part of the development of this MMIA. This modelling was used to predict how far sound from the seismic survey is predicted to travel underwater. Model results indicate the distance from the acoustic source at which marine mammals will be sufficiently protected from behavioural and physiological effects associated with underwater noise. The results indicated that the predicted sound levels will be compliant with the thresholds stipulated in the Code of Conduct for behavioural and physiological effects; hence the standard mitigation zones (defined by the Code of Conduct) have been adopted.

In addition to compliance with the Code of Conduct, Schlumberger has committed to the following actions to avoid, remedy or mitigate potential adverse effects of the Pegasus Basin Seismic Survey on the biological, social, cultural and commercial environment:

- Seismic operations will continue around the clock (as possible) and will utilise continuos line acquisition (acquiring seismic data through the turns) to reduce the overall duration of the survey;
- The vast majority of seismic operations will occur outside 12 nm, hence effects on coastal species & larvae will be minimised;
- Marine mammal sightings will be collected whilst on transit to and from the Operational Area to the local port and also during the length of the survey;
- MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea;
- Weekly MMO reports to be provided to the regulators; and
- Schlumberger will consider covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings.

In summary, the potential effects of the proposed seismic operations are considered to be appropriately managed by the mitigation measures noted above. On this basis it is considered that any significant behavioural or physiological effects on marine mammals are unlikely.

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ABBREVIATIONS AND DEFINITIONS

AIS	Automatic Identification System
CMA	Coastal Marine Area
Code of Conduct	2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations
COLREGS	International Regulations for the Prevention of Collisions at Sea 1972
CRMS	Craft Risk Management Standard for Vessel Biofouling
DOC	Department of Conservation
ECSI	East Coast South Island
EEZ	Exclusive Economic Zone
EEZ ACT	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EPA	Environmental Protection Authority
ERA	Environmental Risk Assessment
FMA	Fisheries Management Area
IAPPC	International Air Pollution Prevention Certificate
HIS	Import Health Standard for Ships Ballast Water
IOPPC	International Oil Pollution Prevention Certificate
ISPPC	International Sewage Pollution Prevention Certificate
IUCN	International Union for Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships 1973
MMIA	Marine Mammal Impact Assessment
MMO	Marine Mammal Observer
MMMP	Marine Mammal Mitigation Plan
NABIS	National Aquatic Biodiversity Information System
NIWA	National Institute of Water and Atmospheric Research
PAM	Passive Acoustic Monitoring
PPP	Petroleum Prospecting Permit
RAMSAR	Convention on Wetlands of International Importance
RMA	Resource Management Act 1991
SEL	Sound Exposure Level
SOPEP	Ship Oil Pollution Emergency Plan
STLM	Sound Transmission Loss Modelling
TACC	Total Allowable Commercial Catch
WCSI	West Coast South Island

1 INTRODUCTION

1.1 Background

Schlumberger New Zealand (Schlumberger) is proposing to acquire a three dimensional (3D) marine seismic survey in the East Coast and Pegasus Basins. The Operational Area, within which all seismic acquisition (~16,000 km^2) will occur, is illustrated in **Figure 1** and is located inside Petroleum Prospecting Area (PPP) 60264. PPP 60264 extends from Cape Kidnappers (Hawke's Bay) in the north to Conway Flats (North Canterbury) in the south. Although the PPP Area does not adjoin the coast, it does include a small section of the territorial sea in the vicinity of Castlepoint (Wairarapa). This survey is referred to as the 'Pegasus Basin Seismic Survey'.

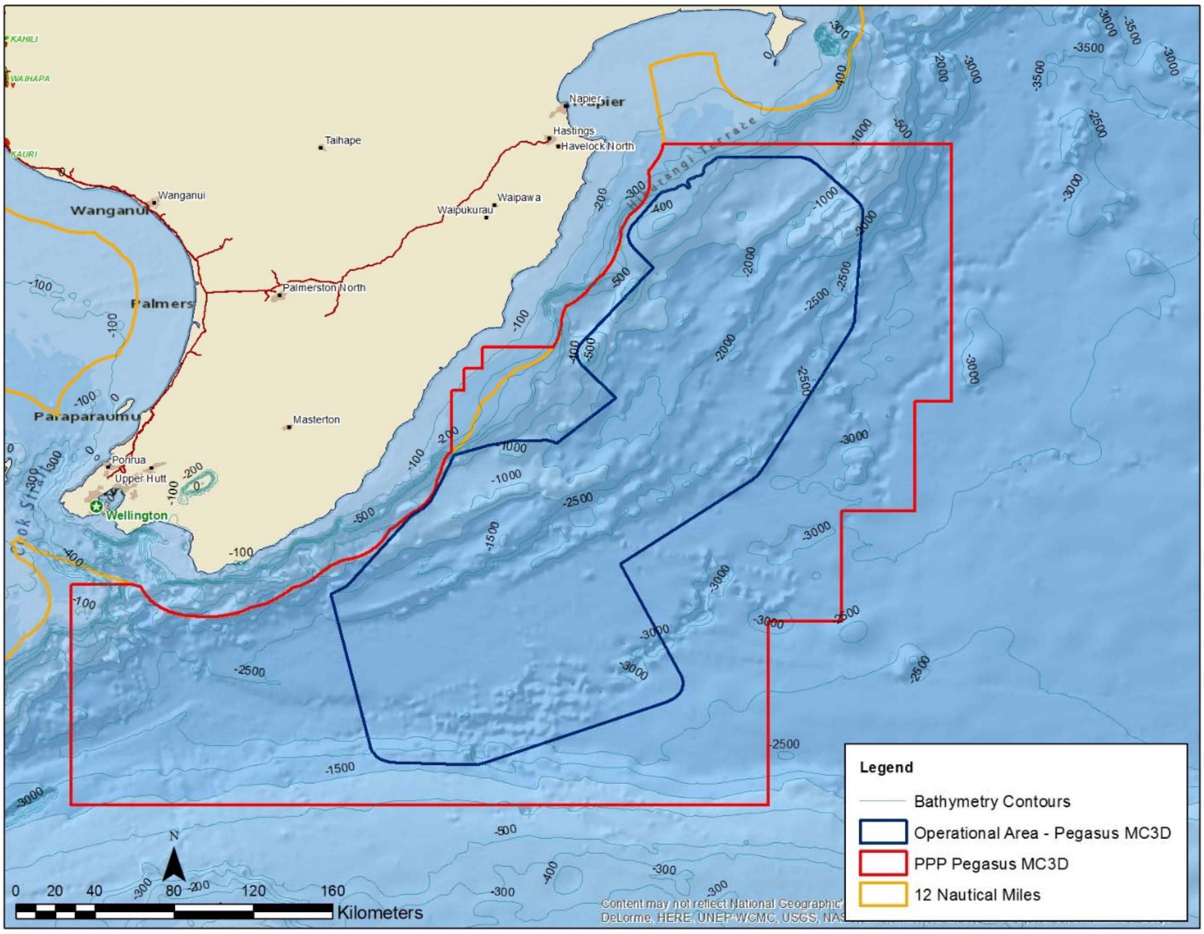
A Petroleum Prospecting Permit application (PPP: permit no. 60264.01) has been lodged with the NZ Petroleum and Minerals which facilitates the prospecting activities. Under Section 23 of the Crown Minerals Act 1991, the purpose of a PPP is to authorise the holder to undertake activities for the purpose of identifying petroleum deposits through geological or geophysical surveying. Further details in regard to the Crown Minerals Act are provided in **Section 3.1**.

The 'Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects – Permitted Activities) Act' (EEZ Act) came into effect in June 2013. The EEZ Act managed the previously unregulated potential for adverse environmental effects of activities within the EEZ and continental shelf. Under the EEZ Act, a marine seismic survey is classified as a permitted activity, providing the operator undertaking the survey complies with the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations' (Code of Conduct) (DOC, 2013). The Code of Conduct is summarised in **Section 3.5**.

A Marine Mammal Impact Assessment (MMIA) has been prepared in accordance with the Code of Conduct in order to assess the potential environmental effects from the Pegasus Basin Seismic Survey on the marine habitats and species in the surrounding area. The MMIA also sets out the mitigation measures that will be implemented to avoid or minimise any potential environmental effects.

Schlumberger are planning to undertake this seismic survey between November 2016 and June 2017. The survey will have an approximate duration of six months; however the exact duration will be dependent on down-time for weather and marine mammal encounters. A WesternGeco purpose-built seismic vessel (*M/V Amazon Warrior*) will undertake the survey.

Figure 1 Location Map and Operational Area of the Pegasus Basin Seismic Survey



1.2 General Approach

This MMIA is a pre-requisite to ensure that Schlumberger undertakes seismic operations in adherence to the EEZ Act (permitted activities regulations) and the Department of Conservation (DOC) Code of Conduct. As well as the Code of Conduct, Schlumberger will operate in accordance with relevant New Zealand legislation, international conventions and their relevant internal environmental standards.

The Pegasus Basin Seismic Survey is classified as a 'Level 1 Survey' by the Code of Conduct and Schlumberger will comply with the relevant requirements while conducting their survey. The Code of Conduct requirements of a Level 1 seismic survey are outlined in **Section 3.5**, and **Section 6** summarises all the measures that Schlumberger proposes to minimise their environmental effects.

During the preparation of this MMIA, an extensive review of literature and existing data on the environment surrounding the Operational Area has been undertaken (see **Section 4**). A full list of references is presented in **Section 8**.

1.3 Stakeholder Engagement

Schlumberger has engaged with existing interests, stakeholders, and tangata whenua in relation to the Pegasus Basin Seismic Survey. These groups were identified based on the geographical extent of the Operational Area. This engagement process involved discussions and communications with groups either in person or by email. All groups that were considered as part of the engagement process are listed in **Table 1.**

Table 1 Groups with which contact has been made

Iwi	
Ngāi Tahu *	Ngāti Kahungunu ki Tararua
Rangitane o Wairarapa *	Ngāti Kahungunu ki Wairarapa *
Te Taiwhenua o Heretaunga *	Ngāti Kahungunu ki Tamaki Nui a Rua *
Maungaharuru Tangitu Trust	Ngāti Kahungunu Iwi Incorporated *
Iwi Collective Partnership	Poronia Hineana Te Rangi Whanau
Rongomaiwahine Iwi Trust	Manu Ahuriri Incorporated
Port Nicholson Block Settlement Trust	Taranaki Whanui o te Upoko o te ika
Other	
Department of Conservation – Wellington *	Hawke's Bay Regional Council
Department of Conservation – Napier *	Greater Wellington Regional Council *
Environmental Protection Authority *	Deepwater Group *
Barine Developments (Scampi company)	NIWA
Sanfords	
** Those groups with which face-to-face meetings occurred*	

The information sheet provided in **Appendix A** formed the basis of the consultation process. A full consultation register capturing key points of the formal engagement is included as **Appendix B**.

The primary commitments made by Schlumberger during consultation are summarised here:

- Opportunities for iwi observers will be provided;
- Liaison with commercial fishers during the survey and avoidance of areas through discussion with fishers;
- Undertake a fisheries assessment to see potential conflict areas between the Operational Area and fishing areas;
- Confirm that there are no acoustic surveys planned for the Operational Area during the survey; and
- Provision of survey acquisition area once finalised.

All of these commitments were completed by Schlumberger.

1.4 Research

The Code of Conduct states that during marine seismic surveys, research opportunities relevant to the local species, habitats and conditions should be undertaken where possible in order to increase the understanding of the effects of seismic surveys on the marine environment (DOC, 2013).

In accordance with the Code of Conduct, and within 60 days following the completion of the Pegasus Basin Seismic Survey, a Marine Mammal Observer (MMO) report is to be submitted to DOC. This report includes all marine mammal observation data collected, including where shut downs occurred on account of marine mammal presence. In addition to this, raw datasheets must also be provided to DOC within 14 days of completion of each swing. The provision of this information to DOC is the primary way in which Schlumberger will contribute to research, whereby the resulting data is incorporated into the national marine mammal sighting database and is then accessible to third parties for research purposes on request. Records collected during the proposed seismic operations will therefore assist with knowledge of marine mammal distributions in the Operational Area.

New Zealand is a hotspot for marine mammal strandings. Since 1840, more than 5,000 strandings of whales and dolphins have been recorded around the New Zealand coast. During any stranding event, DOC is responsible for all aspects of stranding management: including whether or not a necropsy will be undertaken to investigate the cause of death. Despite no scientific evidence that whale strandings are linked to seismic surveys, marine mammal strandings in the vicinity of a seismic survey are often targeted for necropsy to investigate potential acoustic injury. Schlumberger will consider covering the costs associated with a necropsy if a dead marine mammal is found inshore of the Operational Area during acquisition and within two weeks of the end of the Pegasus Basin Seismic Survey. Any resultant necropsy data would also be of benefit to the research community.

2 PROJECT DESCRIPTION

2.1 Marine Seismic Surveys - overview

The basic principle behind a marine seismic survey is that a seismic vessel tows an acoustic source which releases compressed air in a directionally focused acoustic wave at low frequency that travels several kilometres down through the earth. As the acoustic wave travels through the earth, portions are reflected by the underlying rock layers and the reflected acoustic wave is recorded by hydrophones which are located in the towed streamers. The recorded data allows geologists to calculate and map the depths and spatial extent of geological strata, based on the time difference between the generated and received waves.

2.1.1 2D and 3D Surveys

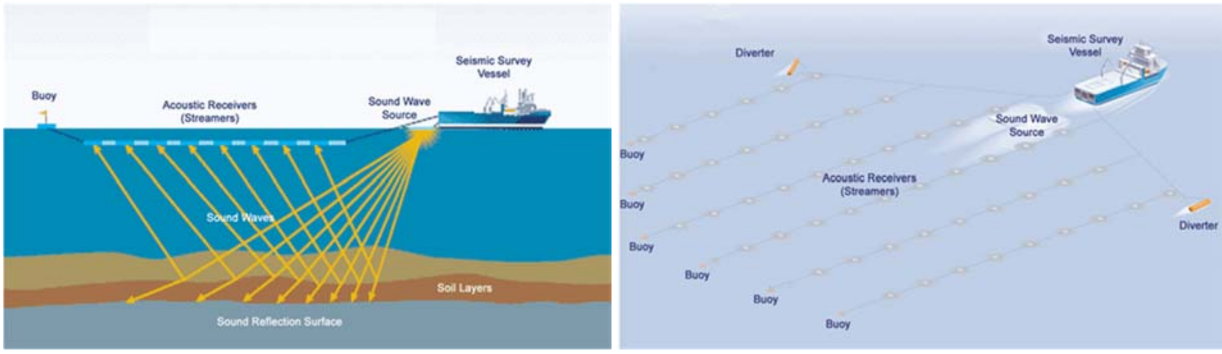
Marine seismic surveys fall into two main categories of varying complexity: 2-Dimensional (2D) and 3-Dimensional (3D) surveys. A 2D survey can be described as a fairly basic survey method which involves a single source and a single streamer towed behind the seismic vessel (**Figure 2**). In contrast, a 3D survey is a more complex method which involves a greater span of more sophisticated equipment.

The 2D surveys are commonly used for frontier exploration areas in order to acquire a general understanding of the regional geological structure and to identify prospective survey areas, which are then comprehensively examined through a 3D survey at a later date.

Wheras the 3D seismic surveys focus on a specific area over known geological targets that are considered likely to contain hydrocarbons. Extensive planning is undertaken to ensure the survey area is precisely defined and the acoustic parameters are selected in order to achieve the best geological results. 3D surveys produce a three-dimensional image of the subsurface.

For the Pegasus Basin Seismic Survey, sail lines will be separated by 1 km. The seismic vessel will tow an acoustic array and 14 streamers (containing hydrophones) at separations of 100 m (**Figure 2**).

Figure 2 Schematic of 2D (left) and 3D (right) Marine Seismic Survey



(Source: www.fishsafe.eu)

2.1.2 Underwater Sound

Underwater sound has two primary measures:

- The amplitude (or relative loudness) is expressed by the decibel (dB) system which is a logarithmic scale that represents a ratio that must be expressed in relation to a reference value; and
- The frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in Hertz (Hz), or cycles per second.

Sound levels in water are not the same as sound levels in air and confusion often arises when trying to compare the two. The reference level of the amplitude of a sound must always be specified. For sounds in water, the reference level is expressed as 'dB re 1µPa' – the amplitude of a sound wave's loudness with a pressure of 1 microPascal (µPa). In comparison, the reference level for sound in air is dB re 20 µPa. The amplitude of a sound wave depends on the pressure of the wave as well as the density and sound speed of the medium through which the sound is travelling (e.g. air, water, etc.). As a result of environmental differences, 62 dB must be subtracted from any sound measurement underwater to make it equivalent to the same sound level in the air.

Although sound travels further in water than it does in air (due to water being denser), in both air and water, the loudness of a sound diminishes as the sound wave radiates away from its source. In air, the sound level reduces by 10 dB as the distance doubles, while in water sound level reduces by 6 dB for each doubling of distance. Underwater sounds are also subject to additional attenuation as they interact with obstacles and barriers (e.g. water temperature differences, currents, etc.). Given the sound level in water reduces by 6 dB as the distance doubles, high levels of sound are only experienced very close to the source. Furthermore, the loudness of a sound in water diminishes very quickly close to the source and more slowly at distance from the source.

The ocean is a naturally noisy environment. Natural sound inputs include wind, waves, marine life, underwater volcanoes and earthquakes. Man-made sounds such as shipping, fishing, marine construction, dredging, military activities, sonar etc. further add to the underwater noise profile.

Table 2 provides a comparison between the amplitude of sound produced during seismic surveys with other underwater noises (man-made and natural).

Table 2 Sound Comparisons in Air and Water

Type of Sound	In Air (dB re 20µPa @ 1m)	In Water (dB re 1µPa @ 1m)
Threshold of Hearing	0	62
Whisper at 1 metre	20	82
Normal conversation in restaurant	60	122
Ambient sea noise	-	100
Blue whale	-	190
Live rock music	110	172
Thunderclap or chainsaw	120	182
Large ship	-	200
Earthquake	-	210
Seismic array at 1 metre	158 – 178	220 – 250
Colliding iceberg	-	220
Bottlenose dolphin	-	225
Sperm whale click	-	236
Jet engine take-off at 1 metre	180 dB	242
Volcanic eruption	-	255

2.1.3 The Acoustic Source

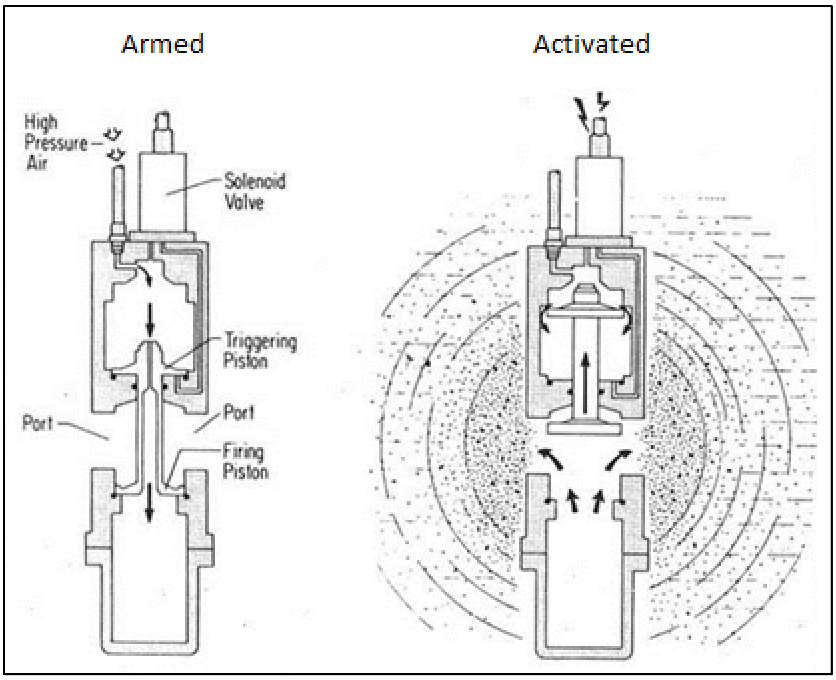
The acoustic source that is towed behind the seismic vessel typically has two arrays which each have a varying number of independent elements. Each element is comprised of high pressure chambers; an upper control chamber and a discharge chamber. High pressure air (~2,000 psi) from compressors on-board the seismic vessel is continuously fed to each element, forcing a piston downwards. The chambers then fill with high-pressure air while the piston remains in the closed position (**Figure 3**).

Each element is activated by sending an electrical pulse to the solenoid valve which opens, and the piston is forced upwards, allowing the high pressure air in the lower chamber to discharge to the surrounding water. The discharged air forms a bubble, which oscillates according to the operating pressure, the depth of operation, the water temperature and the discharge volume. Following this discharge, the piston is forced back down to its original position by the high-pressure air in the control chamber, allowing the sequence to be repeated. The compressors are capable of re-charging the acoustic source rapidly and continuously enabling the source arrays to be fired every few seconds.

Acoustic arrays are designed so that they direct most of the sound energy vertically downwards, although there is some residual energy which dissipates horizontally into the surrounding water. The amplitude of sound waves generally declines with lateral distance from the acoustic source, and the weakening of the signal with distance (attenuation) is frequency dependent, with stronger attenuation at higher frequencies. The decay of sound in the sea is dependent on the local conditions such as water temperature, water depth, seabed characteristics and depth at which the acoustic signal is generated.

Acoustic arrays used by the oil and gas industry typically emit most of their energy at low frequencies of less than 500 Hz (Potter *et al.,* 2007), but higher frequencies (up to 150 kHz) also contribute to the emitted energy (Goold & Coates, 2006). Source levels range from ~222 – 264 dB when measured relative to a reference pressure of one micro-pascal (re 1µPa-$m_{p\text{-}p}$) (Richardson *et al*., 1995). However, the overall amplitude depends on how many elements are in each array. There are typically two identical arrays that are activated alternatively during a seismic survey.

Figure 3 Schematic of a Typical Acoustic Element in a Seismic Array



2.1.4 The Streamers

When the acoustic source is activated, the hydrophones on the streamers detect the energy that is reflected back up from the geological structures below the seabed. The hydrophones convert the reflected pressure signals into electrical energy that is digitised and transmitted along the streamer to the recording system on-board the seismic vessel.

Towing a streamer underwater removes it from potential acoustic interference from the sea surface. The deeper the tow depth, the quieter the streamer in regard to background surface noises; however this also results in a narrower bandwidth of received data. Typical streamer operating depth ranges from 4 – 5 m for shallow high resolution surveys in relatively good weather, to 8 – 12 m for deeper penetration and lower frequency targets in more open waters. The streamers for the Pegasus Basin Seismic Survey will be towed at a depth of 15 m and streamers will extend 8 km behind the seismic vessel.

Tail buoys are attached to the end of each streamer to provide a hazard warning (lights and radar reflector) indicating the presence of the submerged streamer section, and to act as a platform for positional systems of the streamers.

2.2 Pegasus Basin Seismic Survey

The Pegasus Basin Seismic Survey is proposed to take place off the central east coast of New Zealand (see **Figure 1**). Water depths within the Operational Area range from 400 to 3,250 m.

The seismic vessel *M/V Amazon Warrior* (**Figure 4**) will be used to undertake the survey. Seismic survey parameters are summarised in **Table 3** and discussed below.

During the Pegasus Basin Seismic Survey, 14 solid streamers (Q-Marine Solid™) of approximately 8 km in length will be towed from the seismic vessel. Each streamer will be separated by 100 m. Solid streamers have a number of advantages over fluid filled streamers; they are more robust and resistant to damage (e.g. shark bites), they require less frequent repairs, and they are steerable, allowing greater control of the streamers, resulting in less infill lines and a reduction in the cumulative sound energy introduced into the marine environment. During the survey, the *M/V Amazon Warrior* will be travelling at between four and five knots.

The acoustic source will be comprised of three sub-arrays, with a total effective volume of 5,085 in³. The sub-arrays will be towed at an average depth of 7.5 m below the sea surface. Sound Transmission Loss Modelling (STLM) was conducted based on the specific acoustic source volume and array configuration described here. The STLM is further discussed in **Section 5.1.2.1** and the full STLM results are attached as **Appendix C**.

A point of difference between the Pegasus Basin Seismic Survey and other seismic surveys is that the Pegasus Basin Seismic Survey will run a system of ‘continuous line acquisition’, by shortening the lines and acquiring data during the turms Schlumberger can optimise vessel use and reduce the overall duration of the survey.

The acoustic source will have an operating pressure of 2,000 psi and will be activated at a source-point interval of 18.75 m. This equates to source activation every 8 seconds.

Schlumberger are planning to carry out the proposed Pegasus Basin Seismic Survey between November 2016 and June 2017. Subject to weather conditions and marine mammal encounters within mitigation zones, the seismic operations will be conducted 24 hours per day, seven days per week. This survey is expected to take approximately six months to complete.

The technical specifications of the *M/V Amazon Warrior* are provided in **Table 3**. Seismic survey vessel crew changes will occur via helicopter during the Pegasus Basin Seismic Survey. A support vessel will be contracted for the duration of the survey and will be in close proximity to the seismic vessel at all times with the exception of those periods when the support vessel is needed for a port call. A chase vessel will also be utilised during the Pegasus Basin Seismic Survey.

Refuelling of the seismic vessel will be required approximately every 5 weeks throught the Pegasus Basin Seismic Survey. Refuelling will occur at sea, and mitigations around this are discussed in **Section 5.2.3**.

Survey operations can be divided into five main components:

- Mobilisation of seismic vessel to Operational Area;
- Deployment of acoustic equipment: Streamer and array deployment is expected to take approximately 4 days. Once deployed the MMOs will begin the requisite pre-start observations as required under the Code of Conduct when arriving at a new location (**Section 3.5**), followed by a soft start;
- Data Acquisition: Once full acquisition is underway, two MMOs and two PAM operators will maintain watch for marine mammals;
- Retrieval of acoustic equipment; and
- Demobilisation: Once acquisition is complete, the seismic array and streamers will be retrieved and the vessel will head to its next destination or return to port.

If the vessel has to 'wait on weather' during the acquisition period, the source array will typically be retrieved to minimise the likelihood of damage. The streamers, however, will only be retrieved in extreme situations.

Table 3 Seismic Survey Specifications

Parameter	Specifications
Source type	Delta 3 Source Array
Total array volume	5,085 in^3
Maximum predicted output	215 dB re 1μPa/Hz @ 1m
Number of sub-arrays	3
Number of acoustic sources per sub-array	8 - 8 - 8
Nominal operating pressure	2,000 psi
Source Frequency	18.75 m
Tow Depth	Average 7.5 m
Number of streamers	14
Streamer length	8 km
Streamer manufacturer/model	Q-Marine Solid Streamers
Towing depth	15 m

Table 4 Seismic Vessel Technical Specifications

General Specifications	
Vessel Name	*M/V Amazon Warrior*
Vessel Owner	GecoShip AS
Maritime Operator	WesternGeco
Engine Details	2 x Wartsila W9L32 each 4500kW, 2 x PTI each 2500kw/690V
Fuel Capacity	3,941 t (MGO)
Dimensions and capacities	
Vessel Length	126 m
Vessel Beam	32 m
Max Draft	7.6 m
Gross Tonnage	21,195 gross tonnes
Cruising Speed	14 knots

Figure 4 Seismic Vessel – *M/V Amazon Warrior*

2.3 Navigational Safety

During the Pegasus Basin Seismic Survey, the seismic vessel will be towing 14 streamers of approximately 8 km in length, severely restricting its manoeuvrability. Avoidance of collision will rely on all vessels obeying the International Regulations for the Prevention of Collisions at Sea (COLREGS) 1972. COLREGS is implemented in New Zealand waters under the Maritime Transport Act 1994. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the presence of the seismic vessel in the Operational Area and the vessel's restriction in ability to manoeuvre while the streamers are deployed. The *M/V Amazon Warrior* has Automatic Identification System (AIS) technology on-board, allowing the vessel to receive information about the positions of other vessels and to transmit information about its position to others.

All known users of the Operational Area have been provided with information about the survey during the consultation process and Schlumberger will update fishing fleets on their intended schedule closer to survey commencement. Furthermore, the support and chase vessels will be utilised to notify boats that are unaware of the seismic operations as necessary. In accordance with International Maritime Law, the survey vessels will display the appropriate lights and day shapes while undertaking the survey. Tail buoys equipped with a light and radar reflector will mark the end of the streamers, allowing for detection during day and night.

2.4 Survey design – Alternatives and Mitigations

The majority of seismic surveys conducted worldwide use acoustic sources as they generate low frequency signals allowing the formation of images of the underlying geology below the seafloor. Schlumberger will use a 'Delta 3 Source Array' for the Pegasus Basin Seismic Survey, with the acoustic source consisting of three sub-arrays.

The source level and array configuration was selected in order to provide sufficient power to ensure that the geological objective of the survey could be fulfilled, whilst minimising acoustic disturbance.

A source level of 5,085 in^3 has been identified as an optimum power level given the survey objectives.

Seismic operations will be undertaken from November 2016 to June 2017 to take advantage of settled weather. This timing not only makes for more amenable working conditions for crew, but also serves to reduce environmental effects in the following ways:

- Minimises down-time to ensure that the duration of the survey is as short as possible; and
- Minimises overlap with winter baleen whale migrations through the Operational Area.

3 LEGISLATIVE FRAMEWORK

The NZ Government's oil, gas, mineral and coal resources are administered by NZ Petroleum & Minerals and are often regarded as the Crown Mineral Estate. The role of NZ Petroleum & Minerals is to maximise the gains to NZ from the development of mineral resources, in line with the Government's objectives for energy and economic growth.

The legislative framework, relating to the Pegasus Basin Seismic Survey is described below.

3.1 Crown Minerals Act 1991

The Crown Minerals Act 1991 sets the broad legislative framework for the issuing of permits for prospecting, exploration and mining of Crown-owned minerals in New Zealand, which includes those minerals found on land and offshore to the boundary of the extended continental shelf. This act was amended in May 2013.

The Crown Minerals Act regime comprises the Crown Minerals Act 1991, two minerals programmes (one for petroleum and one for other Crown-owned minerals), and associated regulations. Together, these regulate the exploration and production of Crown-owned minerals (NZP&M, 2016).

The Petroleum Minerals Programme 2013 applies to all applications for permits for petroleum activities. It sets out the policies and procedures to be followed for the allocation of petroleum resources, while the requirements to be met by permit holders are defined in the regulations. The programme also defines specific requirements for consultation with iwi and hapū, including the matters that must be consulted on (such as all permit applications) and the consultation principles.

3.2 Marine Mammals Protection Act 1978

DOC administers and manages all marine mammal sanctuaries in accordance with the Marine Mammals Protection Act 1978 (and associated general policy). Marine mammal sanctuaries are established to provide protection of marine mammals from harmful human impacts, particularly in sensitive areas such as breeding grounds, migratory routes and the habitats of threatened species. There are currently six gazetted marine mammal sanctuaries along the coast of New Zealand, plus one whale sanctuary which was established under the Kaikoura (Te Tai o Marokura) Marine Management Act 2014.

A marine mammal sanctuary does not necessarily exclude all fishing, oil or gas activities or seabed mining activities; however, restrictions can be placed on these activities in order to prevent or minimise disturbance to marine mammals. In order to conduct a seismic survey within a marine mammal sanctuary, an operator must notify the Director-General of Conservation and submit a written Environmental Impact Assessment not less than three months before commencing the survey. The operator must also comply with any additional conditions that are imposed by DOC relating to operations within the sanctuary.

The closest marine mammal sanctuary to the proposed Operational Area is the Clifford and Cloudy Bay Marine Mammal Sanctuary which is located approximately 8 km to the west of the Operational Area. The next closest protected area of significance to marine mammals is the Kaikoura Whale Sanctuary (Te Rohe o Te Whanau Puha) which lies 20 km to the west of the Operational Area. A full description of the sanctuary can be found in **Section 4.3.3**

In the territorial sea and in waters outside the EEZ, but over the Continental Shelf, compliance with the Code is voluntary and is neither legally binding nor enforceable. Schlumberger will comply with the Code of Conduct through the entire Operational Area.

3.3 Resource Management Act 1991

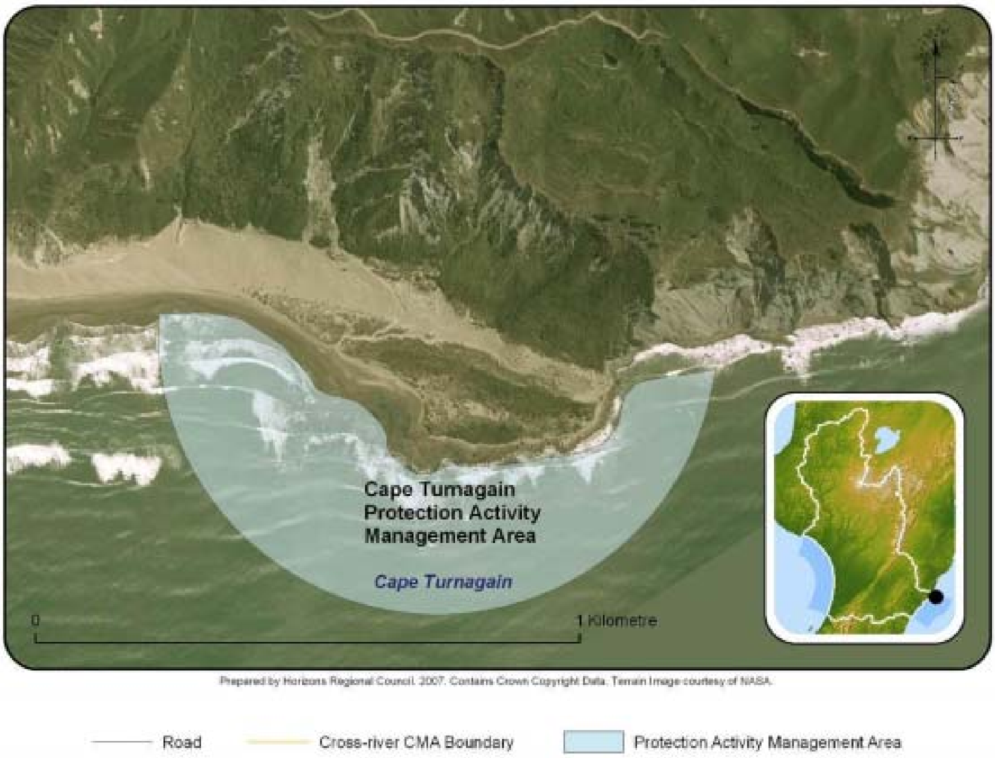
The Resource Management Act 1991 (RMA) aims to promote the sustainable management of natural and physical resources. In the marine environment, the RMA applies to the 'territorial sea' or 'coastal marine area' (from low water out to 12 Nm). Section 16 of the RMA states that "every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on or under a body of water or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level".

In addition, the Proposed Natural Resources Plan for the Wellington Region (which was notified on 31 July 2015) includes a policy (P151) that relates to underwater noise. This policy states that "Use and development in the coastal marine area shall be managed to minimise the adverse effects of underwater noise on the health and well-being of marine fauna and the health and amenity values of users of the coastal marine area".

Policy 18-42 of the Horizon's One Plan stipulates that 1) any seismic operation must be located at least 1 km away from the Protection Activity Management Area; and that 2) any seismic exploration must be undertaken in accordance with the Code of Conduct. The Cape Turnagain Protection Activity Management Area extends seaward for a maximum distance of 100 m (**Figure 5**). At its closest point, the Operational Area lies 8 km offshore; hence is well beyond the Protection Activity Management Area.

Schlumberger intends to satisfy section 16 of the RMA, P151 of the Proposed Natural Resources Plan and Policy 18-42 of the One Plan by complying with the Code of Conduct throughout the Operational Area and largely remaining well offshore. The Pegasus Basin Seismic Survey encompasses only a small portion of the territorial sea, with the vast majority of operations occurring beyond the 12 nm territorial sea boundary.

Figure 5 Cape Turnagain Protection Activity Management Area



3.4 Exclusive Economic Zone & Continental Shelf (Environmental Effects) Act 2012

The EEZ Act came into force in June 2013, and established the first comprehensive environmental consenting regime for activities in NZ's EEZ and Continental Shelf. The purpose of the EEZ Act is to promote the sustainable management of the natural resources of the EEZ and Continental Shelf. Sustainable management involves managing the use, development and protection of natural resources in a way, or at a rate, that enables people to provide for their economic well-being while:

- Sustaining the potential of natural resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;
- Safeguarding the life-supporting capacity of the environment; and
- Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Based on considerations such as effects on the environment or existing interests, protection of rare and vulnerable ecosystems and economic benefit to NZ, the EEZ Act classifies activities within the EEZ and Continental Shelf as:

- **Permitted** – the activity can be undertaken provided the operator meets the conditions specified within the regulations. Seismic surveys fall within this classification and the conditions state that the person undertaking the activity must comply with the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code of Conduct);
- **Non-notified discretionary** – the activity can be undertaken if the applicant obtains a marine consent from the Environmental Protection Authority (EPA), who may grant or decline the consent and place conditions on the consent. The consent application is not publically notified and the EPA has a statutory timeframe of 60 working days in which to process the application;

- **Discretionary** – the activity may be undertaken if the applicant obtains a marine consent from the EPA. The consent application will be notified, submissions will be invited and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 140 working days in which the EPA must assess the consent application; and
- **Prohibited** – the activity may not be undertaken.

The EPA monitors for compliance of seismic surveys with the Code of Conduct, and may conduct audits of seismic vessels before, during or after the survey. The EPA has the authority to take enforcement action in relation to any non-compliant activities (including seismic surveys) within the EEZ.

3.5 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations

The Code of Conduct was developed by DOC to manage the potential impacts of seismic operations on marine mammals. Under the EEZ Act – *Permitted Activities Regulations*, seismic surveys within the EEZ must now comply with the Code of Conduct.

The Code of Conduct aims to:

- 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 observations and reporting;
- Provide for the conduct of seismic surveys in NZ continental waters in an environmentally responsible and sustainable manner; and
- Build effective working relationships between government, industry and research stakeholders.

Under the Code of Conduct, three levels of seismic survey are defined based on the power level of the acoustic array. Level 1 surveys (>427 cubic inches) are typically large scale geophysical investigations, Level 2 surveys (151 – 426 cubic inches) are lower scale seismic investigations often associated with scientific research, and Level 3 surveys (<150 cubic inches) include all small scale, low impact surveys. The Pegasus Basin Seismic Survey is classified as a Level 1 survey. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

3.5.1 Notification

The notification requirements of the Code of Conduct have been met by Schlumberger. A letter was received by the Director-General of Conservation on 7 July 2016 notifying DOC of Schlumberger's intentions to carry out the Pegasus Basin Seismic Survey.

3.5.2 Marine Mammal Impact Assessment

Under normal circumstances, a MMIA must be submitted to the Director-General not less than one month prior to the start of a seismic survey. Each MMIA shall:

- Describe the activities related to the survey;
- Describe the state of the local environment in relation to marine species and habitats, with a particular focus on marine mammals;
- Identify the actual and potential effects of the activities on the environment and existing interests, including any conflicts with existing interests;
- Identify the significance (in terms of risk and consequence) of any potential negative impacts and define the criteria used in making each determination;

- Identify persons, organisations or Tangata Whenua with specific interests or expertise relevant to the potential impacts on the environment;
- Describe any consultation undertaken with persons described above, and specify those who have provided written submissions on the proposed activities;
- Include copies of any written submissions from the consultation process;
- Specify any possible alternative methods for undertaking the activities to avoid, remedy or mitigate any adverse effects;
- Specify the measures that the operator intends to take to avoid, remedy or mitigate the adverse effects identified;
- Specify a monitoring and reporting plan; and
- Specify means of coordinating research opportunities, plans and activities relating to reducing and evaluating environment effects.

3.5.3 Areas of Ecological Importance

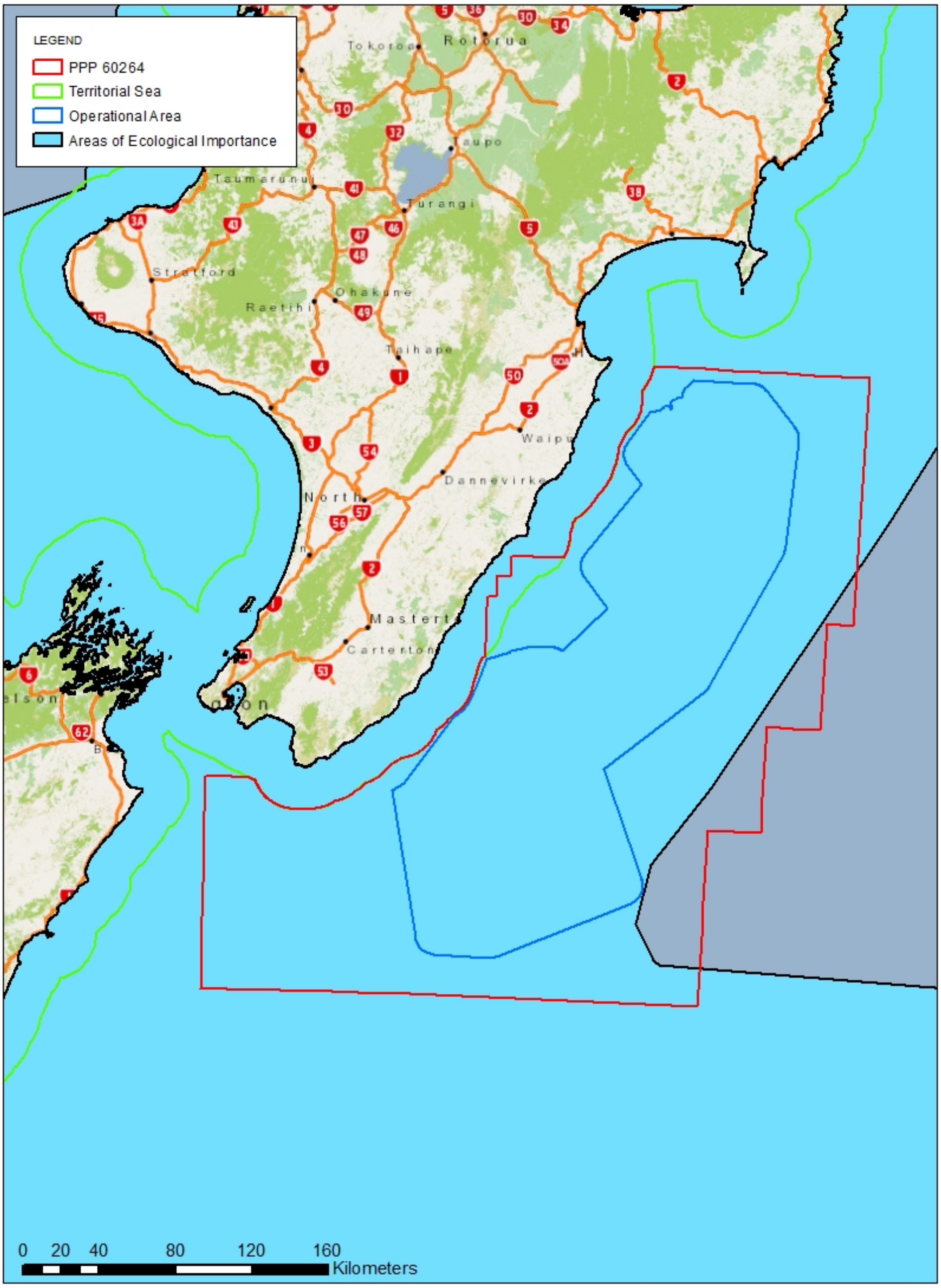
Any seismic survey operations within an Area of Ecological Importance require more comprehensive planning and consideration, including the development of additional mitigation measures.

The extent of the Area of Ecological Importance around New Zealand was determined from DOC's database of marine mammal sightings and strandings, fisheries-related data maintained by the Ministry for Primary Industries, and the National Aquatic Biodiversity Information System (NABIS). Where data was incomplete or absent, technical experts have helped refine the Area of Ecological Importance maps.

The Code of Conduct states that, under normal circumstances, a seismic survey will not be planned in any sensitive, ecologically important areas; during key biological periods where Species of Concern (see **Section 4.2.4.1** for a list of the Species of Concern) are likely to be feeding, migrating, calving, or resting; or where risks are particularly evident such as in confined waters.

The Pegasus Basin Seismic Survey will largely occur within an Area of Ecological Importance (**Figure 6**). A summary of measures that Schlumberger will implement to offset their potential effects in this area is provided in **Section 6**.

Figure 6 Relationship between the Operational Area and Area of Ecological Importance



The Code of Conduct requires STLM to be undertaken for any seismic surveys that will operate within an Area of Ecological Importance. STLM is used to assess the suitability of the mitigation zones outlined in the Code of Conduct by predicting sound propagation whilst accounting for the specific configuration of the acoustic array and the local environmental conditions within the Operational Area (i.e. bathymetry, substrate, water temperature and underlying geology). The model results indicate whether or not the mitigation zones outlined in the Code of Conduct are sufficient to protect marine mammals from behavioural and physiological impacts in accordance with the following thresholds:

- The behavioural threshold is exceeded if marine mammals are subject to Sound Exposure Levels (SELs) greater than 171 dB re 1μPa^2-s; and
- The physiology threshold is exceeded if marine mammals are subject to SELs greater than 186 dB re 1μPa^2-s (also known as the injury threshold).

If the modelling predicts that these thresholds could be exceeded, then consideration must be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. Results from the Pegasus Basin Seismic Survey STLM are discussed in **Section 5.1.2.1**.

3.5.4 Observer Requirements

All Level 1 seismic surveys require the use of MMOs in conjunction with Passive Acoustic Monitoring (PAM). MMOs visually detect marine mammals while the PAM system detects marine mammal vocalisations with hydrophones and is overseen by PAM operators. MMOs and PAM operators must be qualified according to the criteria outlined in the Code of Conduct.

To undertake a seismic survey in compliance with the Code of Conduct, the minimum qualified observer requirements are:

- There will be at least two qualified MMOs on-board at all times;
- There will be at least two qualified PAM operators on-board at all times;
- The roles of MMOs and PAM operators are strictly limited to the detection and collection of marine mammal sighting data, and the instruction of crew on the Code of Conduct and the crew's requirements when a marine mammal is detected within mitigation zones (including pre-start, soft start and operating at full acquisition capacity requirements);
- At all times when the acoustic source is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain 'watch' for marine mammals; and
- The maximum on-duty shift for an MMO or PAM operator must not exceed 12 hours per day.

If observers (i.e. MMO or PAM operators) consider that there are higher than expected numbers of marine mammals encountered during seismic survey operations, they are required to immediately notify the Director General of Conservation. Adaptive management procedures will be agreed following a discussion between DOC and the Operator. The MMO/PAM team will implement any required adaptive management actions.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans, any such detection will require an immediate shutdown of an active source or will delay the start of operations, regardless of signal strength or whether distance or bearing from the acoustic source has been determined. It is not necessary to determine whether the marine mammal is within a mitigation zone. However, shutdown of an activated source will not be required if visual observations by a MMO confirm the acoustic detection was of a species falling into the category of 'Other Marine Mammals' (i.e. not a Species of Concern).

If the PAM system malfunctions or becomes damaged, seismic operations may continue for 20 minutes without PAM while the PAM operator diagnoses the problem. If it is found that the PAM system needs to be repaired, seismic operations may continue for an additional two hours without PAM as long as the following conditions are met:

- It is during 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 seismic operations when PAM is not operational;
- DOC is notified via email as soon as practicable, stating time and location in which seismic operations began without an active PAM system; and
- Seismic operations with an active source, but without an active PAM system, do not exceed a cumulative total of four hours in any 24 hour period.

3.5.5 Operational and Reporting Requirements

MMOs and PAM operators are required under the Code of Conduct to record and report all marine mammal sightings during the survey. All raw datasheets must be submitted directly to DOC at the earliest opportunity, but no longer than 14 days after the completion of each deployment. A written final trip report must also be provided to DOC at the earliest opportunity, but no later than 60 days after the completion of the project.

The operational duties of MMOs and PAM operators during seismic operations are outlined in **Table 5**.

3.5.6 Pre-start Observations

A Level 1 acoustic source can only be activated if it is within the specified Operational Area and adheres to the following protocol:

- The acoustic source cannot be activated during daylight hours unless:
  - At least one qualified MMO has made continuous visual observations around the source for the presence of marine mammals, from the bridge (or preferably even higher vantage point) using both binoculars and the naked eye, and no marine mammals have been observed in the respective mitigation zones for at least 30 minutes, while no NZ fur seals have been observed in the 200 m mitigation zone for 10 minutes; and
  - Passive acoustic monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the respective mitigation zones.
- The acoustic source cannot be activated during night-time hours or poor sighting conditions (visibility of 1.5 km or less or in a sea state greater than or equal to Beaufort 4) unless:
  - Passive acoustic monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation; and
  - The qualified observer has not detected any vocalising cetaceans in the relevant mitigation zones.

Table 5 Operational Duties of MMOs and PAM Operators

Operational duties	
MMO duties	**PAM operator duties**
Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.	Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.
Continually scan the water surface in all directions around the acoustic source for presence of marine mammals, using a combination of naked eye and high-quality binoculars from optimum vantage points for unimpaired visual observations.	Deploy, retrieve, test and optimise PAM hydrophone arrays.
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards or other appropriate tools.	When on duty, concentrate on continually listening to received signals and/or monitor PAM display screens in order to detect vocalising cetaceans, except when required to attend to PAM equipment.
Record/report all marine mammal sightings, including species, group size, behaviour/activity, presence of calves, distance and direction of travel (if discernible).	Use appropriate sample analysis and filtering techniques.
Record sighting conditions (Beaufort sea state, swell height, visibility, fog/rain and glare) at the beginning and end of the observation period, and whenever there is a significant change in weather conditions.	Record and report all cetacean detections, including, if discernible, identification of species or cetacean group, position, distance and bearing from vessel and acoustic source. Record the type and nature of sound, time and duration over which it was heard.
Record acoustic source power output while in operation, and any mitigation measures taken.	Record general environmental conditions, acoustic source power output while in operation, and any mitigation measures taken.
Communicate with DOC to clarify any uncertainty or ambiguity in application of the Code of Conduct.	Communicate with DOC to clarify any uncertainty or ambiguity in application of the Code of Conduct.
Record/report to DOC any instances of non-compliance with the Code of Conduct.	Record/report to DOC any instances of non-compliance with the Code of Conduct.

In addition to the above normal pre-start observation requirements, when arriving at a new location in the survey programme for the first time, or when returning to the Operational Area following a port call, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless either:

- 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; or
- Where there have been less than two hours of good sighting conditions preceding proposed operations (within 20 Nm of the planned start up position), the source may be activated if:
  - PAM monitoring has been conducted for two hours immediately preceding proposed operations;
  - Two MMOs have conducted visual monitoring in the two hours immediately preceding proposed operations;
  - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the two hours immediately preceding proposed operations;
  - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed operations; and

- No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

3.5.7 Soft Starts

A soft start consists of gradually increasing the acoustic source's power, starting with the lowest capacity acoustic source, over a period of at least 20 minutes and no more than 40 minutes. The operational source capacity is not to be exceeded during the soft start period.

The acoustic source will not be activated at any time except by soft start, unless the source is being reactivated after a single break in firing (not in response to a marine mammal observation within a mitigation zone) of less than 10 minutes immediately following normal operations at full power, and the qualified observers have not detected marine mammals in the relevant mitigation zones. No repetition of the less than 10 minute break period in the commencement of a soft start is allowed under the Code of Conduct.

3.5.8 Delayed Starts and Shutdowns

The results of the STLM indicated that the standard mitigation zones for delayed starts and shutdowns (as outlined in the Code of Conduct) are sufficient to protect marine mammals from behavioural and physiological effects during the Pegasus Basin Seismic Survey. For this reason, Schlumberger has adopted the standard mitigations zones during the Pegasus Basin Seismic Survey as outlined below.

Species of Concern with calves within a mitigation zone of 1.5 km

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

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

Species of Concern within a mitigation zone of 1 km

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

- A qualified observer confirms the group has 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 the group within 1 km of the source, and the mitigation zone remains clear.

Other Marine Mammals within a mitigation zone of 200 m

If during pre-start observations prior to initiation of the acoustic source soft-start procedures, a qualified observer detects a marine mammal other than a Species of Concern within 200 m of the source, start-up will be delayed until:

- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m from the source; or

- Despite continuous observation, 10 minutes has elapsed since the last detection of a NZ 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.

Once all marine mammals that were detected within the relevant mitigation zones have been observed to move beyond the respective mitigation zones, there will be no further delays to the initiation of soft start procedures.

4 ENVIRONMENTAL DESCRIPTION

4.1 Physical Environment

4.1.1 Meteorology

The climate of New Zealand is complex, varying from warm subtropical in the far north to cool temperate in the far south. Anticyclones are a major feature of the weather in the Australian-New Zealand region. These circulation systems migrate eastwards across NZ every six to seven days, with their centres generally passing across the North Island. Overall, anticyclones follow northerly paths in the spring and southerly paths in the autumn and winter.

Between the anticyclones and associated cold fronts are troughs of low pressure orientated northwest to southeast. Cold fronts approaching from the west bring with them an increase in cloud levels and strengthening of north-westerly winds. Periods of rain lasting up to several hours follow the passing of the front. After the front has gone through, the weather conditions change again, this time to cold showery south-westerly winds.

Napier and Wellington weather conditions have been used as indicative for the Operational Area as they are situated at the northern and southern limits of the Operational Area. Weather conditions for both these cities are summarised in **Table 6**.

Table 6 Mean Monthly Weather Parameters at Napier and Wellington

Napier	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	46	56	50	62	62	63	105	47	42	54	48	56
Temp – Avg. daytime (°C)	23	23	22	19	17	14	13	14	16	19	20	22
Temp –avg. night time (°C)	14	14	12	10	8	6	5	5	7	9	10	13
Avg. wind speed (kts)	8	7	7	6	7	7	7	7	7	9	9	8
Max. wind speed (kts)	28	29	35	27	35	32	31	29	30	32	33	35

Wellington	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	30	17	23	32	40	49	28	33	40	47	34	24
Temp – Avg. daytime (°C)	20	21	20	17	15	13	12	13	14	16	17	19
Temp –avg. night time (°C)	14	14	14	12	10	8	7	8	9	11	11	13
Avg. wind speed (kts)	15	13	13	13	13	14	13	13	14	15	15	15
Max. wind speed (kts)	51	47	45	50	46	47	43	48	42	50	43	48

(**Source:** MyWeather2, 2016)

4.1.2 Currents and Waves

New Zealand's coastal current regime is dominated by three components: wind-driven currents, low-frequency currents and tidal currents. The net current flow is a combination of all three components and is often also influenced by the local bathymetry.

New Zealand lies in the path of eastward-flowing currents that are driven by winds blowing across the South Pacific Ocean. This results in New Zealand being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the Roaring Forties westerly winds to the south (Gorman *et al.*, 2005). The anti-clockwise circulation of the gyre is initiated by the winds and is then further modified by the spin of the earth.

As illustrated in **Figure 7**, the oceanography of the Operational Area is complex and dominated by the meeting of warm Subtropical (to the north) and cool subantarctic waters (to the south) in the form of the Subtropical Convergence. This feature encircles the southern hemisphere. In the vicinity of New Zealand, it runs from the south-west of New Zealand, through the Snares depression and towards the north of New Zealand running along the eastern continental shelf break. It is then deflected east by the Chatham Rise which locks it in position and limits the convergence vertically with its shallow bathymetry. The two water masses involved in the creation of the convergence present very different temperatures, salinities, stratification, and nutrient profiles thus creating a highly valuable and biologically productive area along the Chatham Rise (Sutton, 2001).

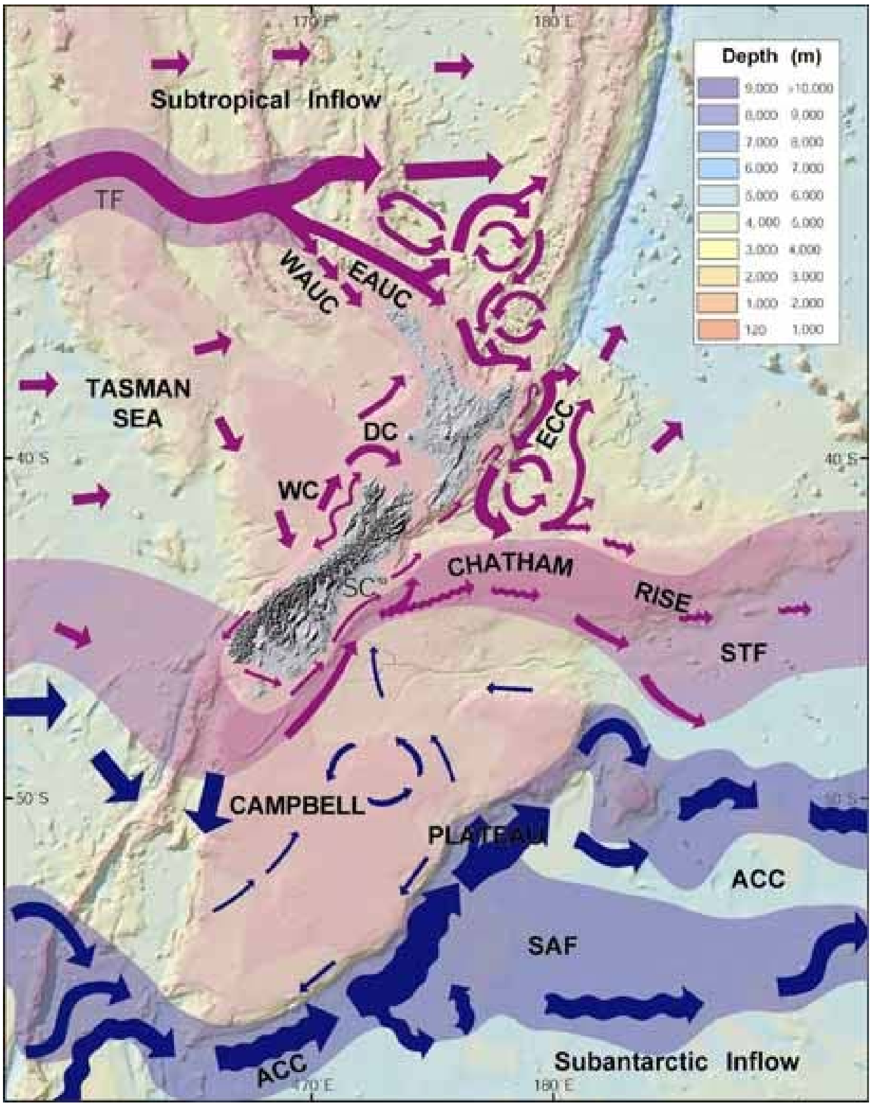
The subtropical water to the north of the convergence is sourced from the Tasman Sea. The eastward flow out of the Tasman splits into two currents across the top of the North Island: the West Auckland Current flowing from Cape Reinga towards Kaipara, and the East Auckland Current flowing from North Cape towards the Bay of Plenty (Brodie, 1960; Heath, 1985; Stanton, 1973). The East Auckland current progresses southward and eventually reaches the East Cape where it gives rise to the East Cape Current. At this point, the East Cape current continues its trajectory around the Cape and along the East Coast of the North Island of New Zealand whereas the East Auckland Current undergoes a dramatic change in direction and flows back northward (Heath, 1982). At Cape Palliser, the East Cape Current turns offshore and then northwards in order to form the outer arm of the East Cape Current system (Heath, 1982).

South of the Operational Area, the Southland Current flows northwards along the eastern coast of the South Island. The current flows through a geological feature known as the Mernoo Saddle. As a result of the change in bathymetry, shallow waters are forced upwards and through the saddle whereas the deeper waters are redirected eastwards along the Chatham Rise (Heath, 1982).

In the vicinity of Kaikoura, the East Cape Current and the Southland current meet with the low-nutrient D'Urville Current water which flows west to east through Cook Strait. This results in the formation of the Wairarapa Coastal Current which flows northeast along the Wairarapa coast (Chiswell, 2000).

A number of semi-permanent eddies can be found within the flow off the East coast of the North Island of New Zealand. Three of these features, including the eddy known as the Wairarapa Eddy, have been identified as permanent (Roemmich & Sutton, 1998). The Wairarapa Eddy is thought to be formed by the retroflection of the East Cape Current by the Chatham Rise (Heath, 1982; Chiswell, 2003).

Figure 7 Ocean Circulation around the New Zealand Coastline.



(Source: Te Ara, 2016: http://www.teara.govt.nz/en/map/5912/ocean-currents-around-New-Zealand)

4.1.3 Thermoclines and Sea Surface Temperature

During spring and summer, thermal stratification of the water column can develop as a result of solar heating of the upper water column (i.e. 40 – 50 m below the sea surface). The stratification profile varies with local environmental conditions: where storm conditions can cause significant vertical mixing and breakdown of the thermal structure, but local tides and currents can either enhance or degrade thermocline structure. As a result, a well-defined thermocline is not always present.

Thermoclines can be observed through processed seismic data. A thermocline is characterised by a negative sound speed gradient and can be acoustically reflective. This is the result of a discontinuity in the acoustic impedance of water created by the sudden change in density associated with the thermocline. Hence, a change in temperature of 1°C can result in a difference in sound speed of 3 ms^{-1} (Simmonds *et al.*, 2004).

The Subtropical front is yet again a dominant feature in the structure of the water column in terms of temperature and salinity. The front itself is typically characterised by steep isotherms. To the north of the front, the mixed layer deepens towards particularly in summer when isotherms are known to be near horizontal with a well-defined seasonal thermocline developed north of Castlepoint (Garner 1959; Chiswell, 2002). Current meter readings in the Wairarapa Eddy indicate that the mixed layer is typically located between 50 and 100 m (Chiswell, 2003) and on a North-South transect (as conducted by Chiswell, 2002), the Wairarapa Eddy is characterised by a '"bowling" of the isotherms.

The spatial structure of salinity is similar to that of temperature (Chiswell, 2002). Subtropical water is more saline that subantarctic water to the south (Chiswell, 2002).

4.1.4 Bathymetry and Geology

NZ is surrounded by a gently sloping zone; the continental shelf. The continental shelf extends from the coast out to a water depth of 100 – 200 m. Beyond the continental shelf, the gradient of the seabed steepens and passes into the continental slope which descends relatively rapidly from the edge of the shelf down to depths in excess of 4,000 m. At the foot of the slope, the gradient flattens out into ocean basins which are a wide undulating but relatively flat zones lying at depths of 4,000 – 5,000 m. These zones cover most central parts of the major oceans (Te Ara, 2016).

The surface of the continental shelf is predominantly flat (punctuated by local banks and reefs), whereas the slope is irregular with large marine valleys (submarine canyons). These canyons tend to occur in slope areas of relatively steep gradient (e.g. off Kaikoura and the Cook Strait) and generally run from the edge of the continental shelf to the foot of the continental slope.

The continental shelf within the Operational Area is extremely narrow. In fact narrowest part of the New Zealand continental shelf is situated between Cape Kidnappers and Kaikoura (1 to 15 nm).

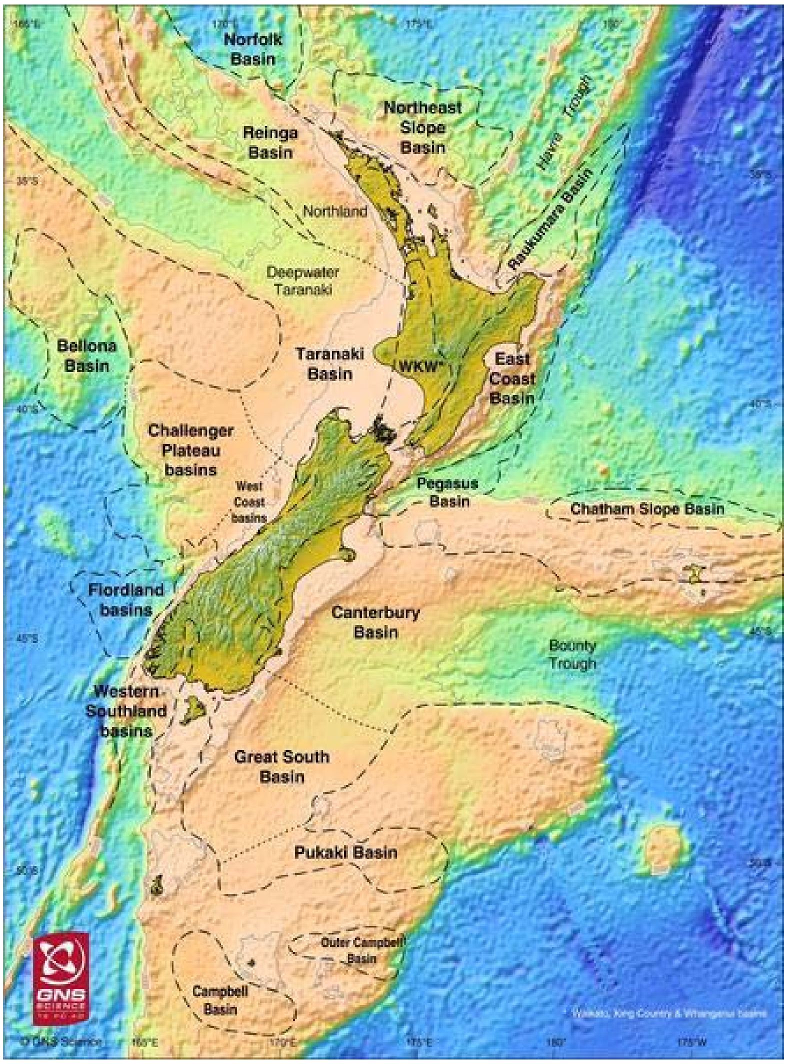
Beyond the continental shelf, the surface of the continental slope is interspersed with numerous canyons (the Cook Strait Canyon, the Pahaua Canyon and the Madden Canyon). All of these canyons flow into the Hikurangi Channel which is located at 2,500 m and is created by the flattening of the continental slope.

Other notable geological features located within the Operational Area include Opouawe Bank methane seeps which are located 16 km offshore from Cape Palliser at a depth of 1,100 m. Additionally, a significant part of the Hikurangi Trough along the East coast of the North Island is known to have methane seepage (MacDiarmid, 2012)

This varied underwater topography is the result of NZ's breakup from Gondwana which created the continental slopes and created sedimentary basins. Rivers eroded the land and transported sediments containing organic matter into these basins. This erosion resulted in the deposition of shoreline sands, followed by marine silts and mud several kilometres thick, compacted by the weights of the overlying sediments. Due to their permeable and porous properties, the deposited materials made ideal hydrocarbon reservoir rock, with impermeable overlying silts, mud and carbonates forming the seals.

There are eight sedimentary basins underlying NZ's continental shelf with known or potential hydrocarbons present (**Figure 8**). To date, commercial quantities of oil and gas have only been produced from the Taranaki Basin.

Figure 8 New Zealand's Sedimentary Basins.

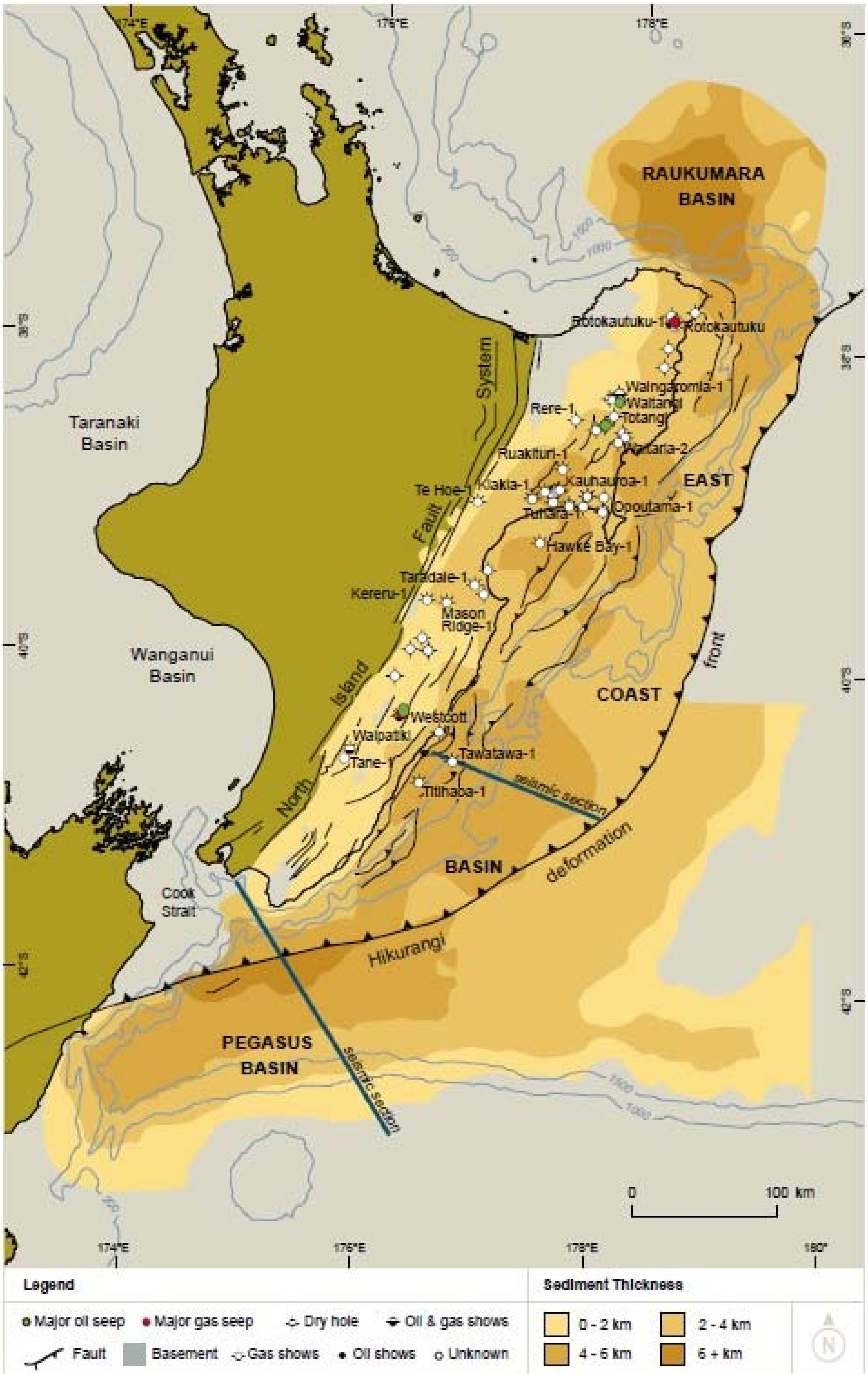


(Source: http://www.gns.cri.nz/Home/Our-Science/Energy-Resources/Oil-and-Gas/NZs-Sedimentary-Basins)

The Pegasus Basin on the east coast of New Zealand is thought to have formed during the early Cretaceous. Subduction of the Hikurangi Plateau below the Chatham Rise proceeded until the mid-late cretaceous at which point the province would have transitioned to a passive continental margin. By early Miocene, the margin has transformed to a convergent margin forearc. Pegasus Basin is located to the West of the modern subduction thrust and as a result is much less deformed than the East Coast Basin. The basin was a depression into which sediments were deposited from the south and west (NZPAM, 2016)

Source rocks in the Pegasus Basin were deposited in marine environments. The main known source rocks are the Whangai and Waipawa formations. Reservoir rocks include transgressive marine sandsones and tudibdite sandstones, fractured late cretaceous-paleocen mudstones, eocen-oligocene greensands, noegene turbidite sandstones, shelf sandstones, and bioclastic limestones.

Figure 9 The East Coast Province



Source: (NZPAM, 2016)

4.2 Biological Environment

4.2.1 Plankton

Plankton is the collective term for drifting organisms that inhabit the pelagic zone (water column) of the world's oceans. Plankton fulfil the role of primary producers in the ocean and form the basis of the marine food web. Plankton travel with the ocean currents and although some plankton can move vertically within the water column, their horizontal distribution is primarily determined by the surrounding currents.

'Plankton' refers to animals, algae, protists, archaea and bacteria. There are three broad functional planktonic groups:

- Bacterioplankton – free-floating bacteria (important in nutrient cycling);
- Phytoplankton – free-floating plants (capable of photosynthesis); and
- Zooplankton – free-floating animals (includes larval stages of larger animals).

Plankton production is subject to the influence of local oceanographic conditions. As mentioned previously, the Operational Area includes a number of notable features which strongly impact primary production in the region.

The Wairarapa Eddy not only creates a region of higher chlorophyll in surrounding waters (resulting from enhanced production or accumulation of chlorophyll) but also impacts the nature of zooplankton assemblages in the area (Bradford & Chapman, 1988). Four groups of zooplankton have been identified in the Wairarapa Eddy: an Eddy Centre Group, an oceanic Northern Group, a mixed group with oceanic and coastal species (Coastal Group) and a Southern Group. Importantly, Bradford & Chapman (1987) concluded that the difference in composition of the groups was not caused by advection but rather by *in situ* biological processes which highlights the importance of the role of the Eddy in local ecological processes.

Moreover, the rock lobster (*Jasus edwardsii)* is known to rely heavily on the Wairarapa Eddy throughout certain parts of its lifecycle. The phyllosoma larvae of this species spend several months offshore and mid-stage larvae make up an important part of the zooplankton assemblages within the Eddy (Booth and Stewart, 1992). More advanced life stages are known to be distributed further inshore as the larvae swim shoreward to settle.

4.2.2 Invertebrates

The Operational Area encompasses a wide range of habitat and substrate types (e.g. mud, sand, boulders, and gravel), depths (400 – 3,250m), temperatures, exposure, and current conditions. These variable environments are host to a diverse range of benthic invertebrate communities. Invertebrate communities present within the Operational Area are broadly described below with coral communities described separately in **Section 4.2.2.1** due to their threatened status and the national importance of some of the Operational Area for New Zealand's corals.

In general, the diversity of gastropods, bivalves, and polychaetes decreases with depth from the shelf to the slope, with the lowest diversity present on the abyssal plain. Polychaetes dominate deep-sea abyssal communities based on abundance, despite a lack in diversity. Isopods show the opposite trend, increasing in diversity with increasing depth (Lörz *et al*., 2012).

Important deep-sea environments within the Operational Area include the Hikurangi Trough, and the Cook Strait. A number of methane seeps (**Section 4.3.2**) are found on the Hikurangi Trough. These seeps host communities reliant on energy supplies by chemosynthetic processes via free-living and symbiotic bacteria. A feature of seep communities is low diversity and high occurrence of endemism. The deep canyons of Cook Strait provide habitat for unique faunal assemblages (MacDiarmid *et al*., 2012). Communities of the Kaikoura Canyon are largely controlled by variation in bathymetry, with high invertebrate biomass a feature of this canyon (De Leo *et al.,* 2010).

Marine sponges are the most common marine invertebrate in New Zealand waters. They are found on hard and soft substrates and throughout all depths in the Operational Area (Kelly, 2015). Sponge communities in the inshore environment are dominated by the Desmospongiae class, with sponges from the class Hexactinellida (the glass sponges) also present in deeper water environments (Kelly, 2015).

Echinoderms inhabit a range of habitats from the intertidal down to the abyss (Mills *et al*., 2014). The deeper water habitats within the Operational Area have a higher diversity of echinoderms compared to inshore habitats, including over 25 species of starfish, 19 brittle, basket and snake stars, 13 sea urchins, 11 sea cucumber, and three species of feather stars and sea lilies (Tracey *et al*., 2011). The majority of echinoderms found within the Operational Area are endemic to New Zealand.

Bryozoans are particularly abundant and diverse in New Zealand waters and given the depth range of the Operational Area it is likely that large areas of bryozoans will be present (MacDiarmid *et al*., 2013).

The mollusc group includes bivalves, grastropods and brachiopods. As depth increases, species composition changes and deepwater species become more prevalent. The mollusca group is notable for its occurrence within coldseep habitats (Boyd, 2009; Baco *et al*., 2010) such as those off the east coast of the North Island.

The polychaete families Spionidae, Terebellidae, Sabellia, Eunicidae, and Nereidae are all notable within the Operational Area’s subtidal as well as deeper offshore waters (Annelida, 2016). Also of importance are species associated with cold seeps, including Chaetopterids, Flabelligerids and the Siboglinids; filter feeding tube dwellers (Boyd, 2009; Baco *et al*., 2010).

The east coast of the North Island is considered to be an important area for rock lobster larvae and juveniles (Te Ara, 2016b), with metamorphosis of larvae thought to occur in the Wairarapa Eddy (Jeffs *et al*., 2001). Rock lobster occur at depths ranging from 5 to 275 m (MarlineLife, 2016). An important commercial rock lobster fishery occurs on the east coast within the Operational Area (see **Section 4.5.2**). Scampi are commonly found in depths ranging from 140 to 640 m (MPI, 2014), with a valuable commercial scampi fishery occurring off the Hawke’s Bay and Wairarapa coasts (see **Section 4.5.2**). Crabs (e.g. paddle crabs, and other lobsters), hermit crabs, isopods, shrimp and prawns are also known to occur throughout the Operational Area.

Consultation with Rangitane has identified the importance of king crabs in the Pegasus Basin and the potential of these species as an underdeveloped fishery. The king crab species *Lithodes aoteroa* and *Neolithodes brodiei* are deep water species; *L. aoteroa* is found in depths of 120 – 700 m and *N. brodiei* is found in 800 – 1,100 m water depths. King crabs aggregate during breeding and moulting. Migrations are also thought to occur between shallow and deep waters in response to moulting and mating. Spawning is thought to occur in summer or autumn (MPI, 2016).

Round worms, ribbon worms and flatworms occur throughout the Operational Area from the shoreline through to deep-sea environments.

4.2.2.1 Corals

New Zealand has a rich and diverse range of corals present from the intertidal zone down to depths of 5,000 m (Consalvey *et al*., 2006). Coral occur either as individuals or as colonies of individual polyps. Deep-sea corals are fragile, sessile, slow-growing and can live for hundreds of years. They have limited larval dispersal and are restricted to certain habitats. As New Zealand's corals are often associated with seamounts and can support highly diverse communities, including commercially viable fish species, they are often targeted by commercial fishers (Consalvey *et al*., 2006). Of the protected marine invertebrate species, deep-sea corals are the most relevant to this MMIA.

The Wildlife Act 1953 protects all species of black coral and stylasterid hydrocoral (formerly known as red coral) in New Zealand waters. These corals are all potentially present in the Operational Area. Otocorals and stony corals are also potentially found in the Operational Area; however, they are not currently protected under the Wildlife Act.

There are 58 species of black coral found in New Zealand waters, and although their depth and geographical distributions have not been systematically analysed, most appear to live on or near seamounts. The majority of New Zealand black corals have been found in 750 – 1,250 m water depths, with small peaks in abundance in shallower waters (Baird *et al*., 2012).

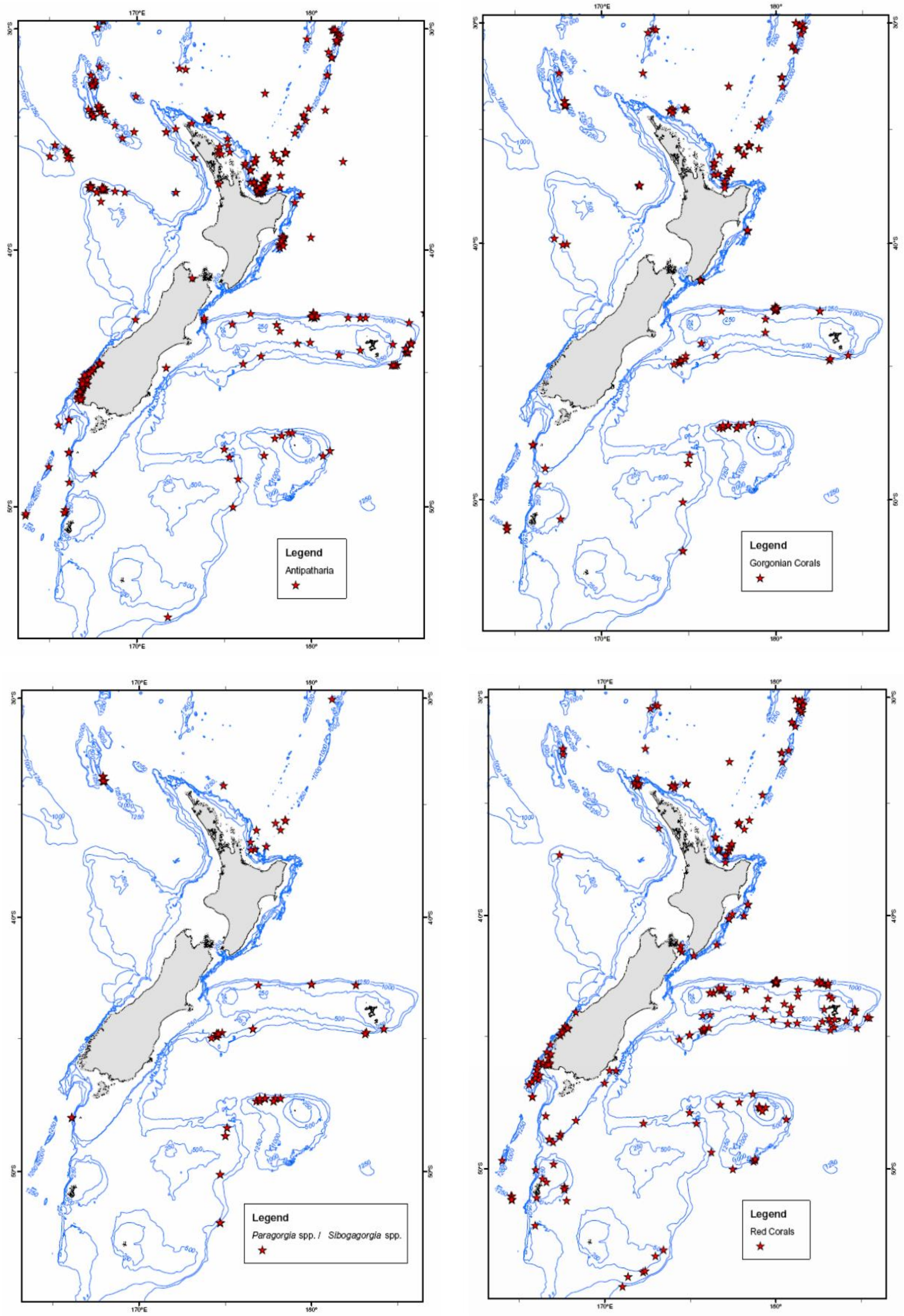
New Zealand waters contain the richest red coral fauna in the world; 80% of the World's described red corals are endemic to New Zealand (Consalvey *et al*., 2006). Red corals have similar depth distributions to black corals (Baird *et al.,* 2012). Red corals are particularly vulnerable to breakage (Consalvey *et al*., 2006).

New Zealand's octocoral community is the most diverse in the World. Octocoral density tends to peak in water depths of 200 – 500 m and 1,000 m (Baird *et al.,* 2012). Gorgonian and bubblegum corals belong to the octocoral class.

Stony corals are the only reef forming corals and inhabit the widest range of depth and temperature. Stony corals have similar depth distributions to octocorals, but with a wider depth range in deeper waters (Baird *et al*., 2012).

Information from trawl surveys and the fishing industry suggest that the presence of all corals appears to increase towards the north and east of New Zealand, with the Chatham Rise supporting a large number of corals (Consalvey *et al*., 2006). It is worth noting that as the Chatham Rise is a major fishing ground therefore increased concentrations of corals in this region may be a result of intense survey effort. Consalvey *et al* (2006) produced distribution maps for corals in New Zealand. These maps suggest that significant densities of corals could be present within the Operational Area, particularly over the Chatham Rise offshore from the Wairarapa and Hawke's Bay coast (**Figure 10)**.

Figure 10 Records of Corals in New Zealand; Black corals (top left), Gorgonian (top right), Bubblegum (bottom left), and Red Corals (bottom right)



Source: Consalvey *et al.* (2006)

4.2.3 Fish Species

New Zealand's waters support a large and diverse range of fish, including demersal and pelagic species. The PPP Area extends over a wide range of depths, from relatively shallow, more coastal waters, out to depths in excess of 2,000 m over areas such as the Cook Canyon, Kaikoura Canyon and Hikurangi Channel.

Fish populations from the Operational Area are represented by various demersal and pelagic species, most of which are widely distributed from north to south and from shallow coastal water to beyond the shelf edge.

A general summary of the fish species potentially present in the Operational Area is presented in **Table 7**. The information for this summary was collated from the NABIS database, O'Driscoll *et al*., (2003); O'Driscoll (2014); Hurst *et al*., (2000).

Table 7 Fish Species Potentially Present in the Operational Area and PPP Area

Common Name		
Ahuru	Golden mackerel	Red snapper
Albacore tuna	Hake	Red mullet
Alfonsino	Hapuku	Ribaldo
Anchovy	Hoki	Rig
Arrow squid	Horse mackerel	Rough skate
Barracouta	Javelin fish	Rubyfish
Banded bellowsfish	John dory	Sand flounder
Banded rattail	Kahawai	Scaly gurnard
Basking shark	Kingfish	Scampi
Bass	Leatherjacket	School shark
Baxter's lantern dogfish	Lemon sole	Short-tailed black ray
Bigeye tuna	Ling	Shovelnose spiny dogfish
Black oreo	Long-finned beryx	Silver dory
Blue cod	Long-nosed chimaera	Silverside
Blue mackerel	Long-nose velvet dogfish	Silver warehou
Blue moki	Lookdown dory	Sea perch
Blue shark	Lucifer dogfish	Slender jack mackerel
Blue/ common warehou	Mako shark	Smooth skate
Bluenose	Moonfish	Smooth oreo
Bollon's rattail	Murphy's mackerel	Snapper
Brill	NZ sole	Southern blue whiting
Broadbill swordfish	Northern spiny dogfish	Spiky oreo
Bronze whaler shark	Oblique banded rattail	Spiny dogfish
Brown stargazer	Oliver's rattail	Spotted stargazer
Carpet shark	Orange perch	Sprat
Common roughy	Orange roughy	Squid
Crested bellowsfish	Pale ghost shark	Tarakihi
Cucumber fish	Pilchard	Thresher shark
Dark ghost shark	Porae	Trevally
Deepsea cardinalfish	Porcupine fish	Turbot

Common Name		
Eagle ray	Porbeagle shark	Two saddle rattail
Elephant fish	Ray's bream	White shark/great white shark
Escolar	Redbait	White warehou
Frostfish	Red cod	Witch
Gemfish	Red gurnard	Yellow-eyed mullet
Giant stargazer		

Areas where fish spawn may be disproportionately important to fish populations; disruptions may result in reduced recruitment (Morrison *et al.,* 2014). There is some evidence of spawning activity by a number of species of demersal or pelagic fish within the Operational Area and PPP Area due to the inclusion of the Chatham Rise and Kaikoura Canyon (areas thought to be important for fisheries, particularly for deepwater species (Baird, 2014)) within the Operational Area's boundaries. Species known to spawn within the Operational Area and PPP Area include; banded giant stargazer, barracouta, blue/common warehou, gemfish, giant stargazer, hake, hapuku, Murphy's mackerel, kahawai, ling, red cod, red gurnard, rig, rough skate, smooth skate, sand flounder, school shark, sea perch, silver warehou, spiny dogfish, tarakihi, trevally, yellow-eyed mullet, blue warehou, black oreo, lookdown dory, shovelnose dogfish, orange roughy, hoki, ribaldo, spiky oreo, and smooth oreo (Hurst *et al*., 2000; O'Driscoll *et al*., 2003).

It is worth noting that there may be other fish species spawning within the Operational Area, however, spawning locations are often not known. As a result only the species with known spawning within the Operational Area have been mentioned.

Although the Hawke's Bay region is not a known spawning ground for blue moki and snapper, it is recognised as a migratory pathway for these species as well as for terakihi and warehou (Morrison *et al*., 2014).

Both long-finned and short-finned eels are present in freshwater systems present along New Zealand's east coast. These eels live the majority of their lives in freshwater systems until they have matured to breeding size. At this stage, adult eels go through physical changes in order to migrate to spawning areas in the Pacific (such as Tonga, however, exact location unknown) (Te Ara, 2016c). There is limited scientific information available regarding specific migration routes of eels; however, eels are believed to migrate from New Zealand to spawning grounds by various routes, with returning larvae travelling on ocean currents via New Zealand's east and west coasts. The Hikurangi Channel, which joins up with the Tonga Trench, is one pathway that may be used by migrating eels (PCE, 2013).

Eight species of fish are listed as protected under Schedule 7A of the Wildlife Act 1953: basking shark, deepwater nurse shark, great white shark, manta ray, oceanic white-tip shark, spiny-tailed devil ray, spotted black grouper, and whale shark. Additionally, the great white, basking and oceanic white-tip sharks are also protected under the Fisheries Act, prohibiting NZ flagged vessels from taking these species from all waters, including beyond New Zealand's EEZ. While all protected species have the potential to be sporadic visitors to the Operational Area, the great white shark and basking shark have the greatest potential to occur in the Operational Area.

4.2.4 Cetaceans

Forty seven cetacean taxa (whales and dolphins) are recognised from New Zealand waters (Baker *et al*., 2010). Taxonomically, cetaceans are split into two suborders: toothed whales (odontocetes) and baleen whales (mysticetes).

Baleen whales are large and use baleen to filter plankton prey from seawater. Odontocetes have teeth, are highly social, and hunt and navigate in large groups. While both groups use sound to communicate, only odontocetes echolocate. Odontocetes direct sounds (“clicks”) into their environment and use the reflected sound waves to interpret their surroundings (identify objects and locate prey). This reliance on sound for communication, feeding and navigation makes cetaceans vulnerable to the effects of anthropogenic noise: therefore precautions must be taken during seismic surveys in order to minimise potential effects. Mitigation measures for the Pegasus Basin Seismic Survey are summarised in **Section 6**.

4.2.4.1 Cetacean Distribution in the Operational Area

Due to their often elusive nature and general inaccessibility, cetaceans are notoriously difficult to study. Furthermore, deep-diving, offshore and migratory species are less well documented due to the logistical challenges that arise from these behaviours. These characteristics mean that cetacean distribution data is largely incomplete; hence it is important to consider multiple sources of information to better understand cetacean occurrence. Information is generally available in the form of detection data (acoustic detections or sightings from dedicated and opportunistic surveys) or can be inferred from stranding information, knowledge of migration paths and habitat preferences of each species.

Interpretation of cetacean distribution data requires caution. In particular, caution should be exercised for those areas that are lacking in sightings data as this does not strictly indicate an absence of cetaceans; rather it could simply reflect a lack of observer effort. These ‘data gaps’ are common in areas that have low levels of boat activity, no dedicated cetacean surveys, or are relatively inaccessible. Furthermore, the DOC sightings database (which is cited throughout this section) is the most comprehensive collation of sightings data in NZ, but it does not include all distribution data.

Similarly, stranding data must also be interpreted with caution. Stranding data is useful to give very broad indication of occurrence but certainly does not give a full representation of species distribution. Stranding data should therefore be interpreted as indicative only, with greater emphasis placed on live sighting data.

This MMIA aims to provide a broad overview of cetaceans which could be present in the Operational Area. It is noteworthy that data collected during the Pegasus Basin Seismic Survey will be a valuable contribution towards better understanding the distribution of cetaceans in these waters.

The data sources utilised to identify cetaceans potentially present within the Operational Area were: the DOC sighting database, the DOC stranding database, Schlumbergers 2014 East Coast 2D seismic survey Marine Mammal Observer report and readily available distribution accounts from the literature.

The DOC sighting database includes over 8,000 sightings of marine mammals, of which numerous records were contributed by previous seismic surveys. **Figure 11** provides a summary of all sightings from the database in the vicinity of the Operational Area.

A summary of DOC stranding data is presented in **Figure 12.** This figure illustrates that strandings occur in all regions of NZ. The data presented is comprised of 40 cetacean species and four pinniped (seal) species. An assessment of the DOC stranding database in the early 1990s concluded that three species, pilot whales, false killer whales and sperm whales, accounted for 88% of all whale strandings (Brabyn, 1991); hence many species are only represented in the stranding database in very small numbers.

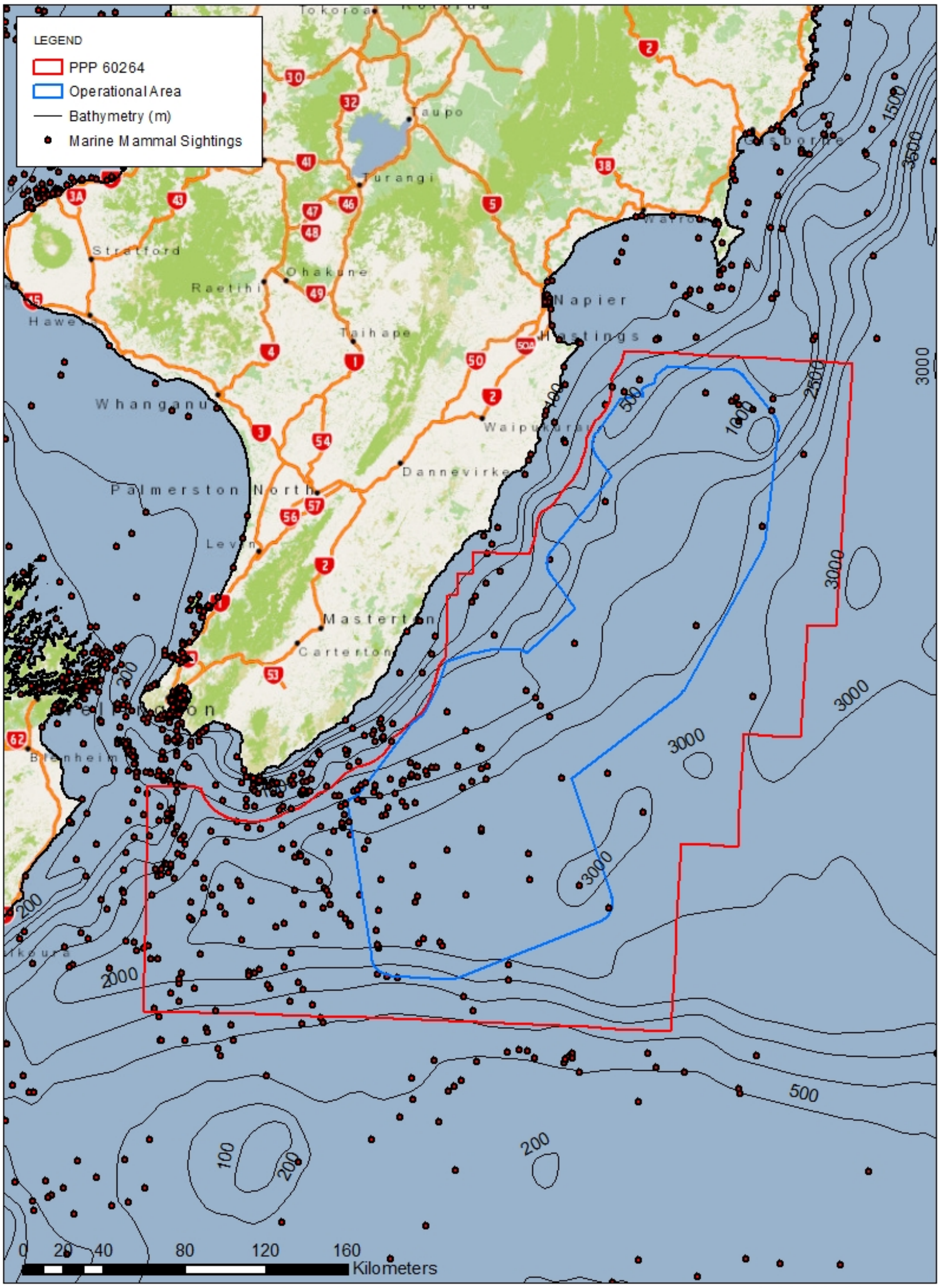
Based on the available information, a summary of cetacean species that could be present in the Operational Area is provided in **Table 8**, and a basic ecological summary for those species considered ‘likely’ to be present in the Operational Area, ‘occasional visitors’ or those considered to be threatened species are provided in **Section 4.2.4.3**.

Criteria used to assess the likelihood of a species being present in the Operational Area are presented below:

- **Likely**
  Species that represented in the DOC sightings and/or stranding record from the Operational Area and which are not classified as 'migrants' or 'vagrant' in the New Zealand Threat Classification System.
- **Possible**

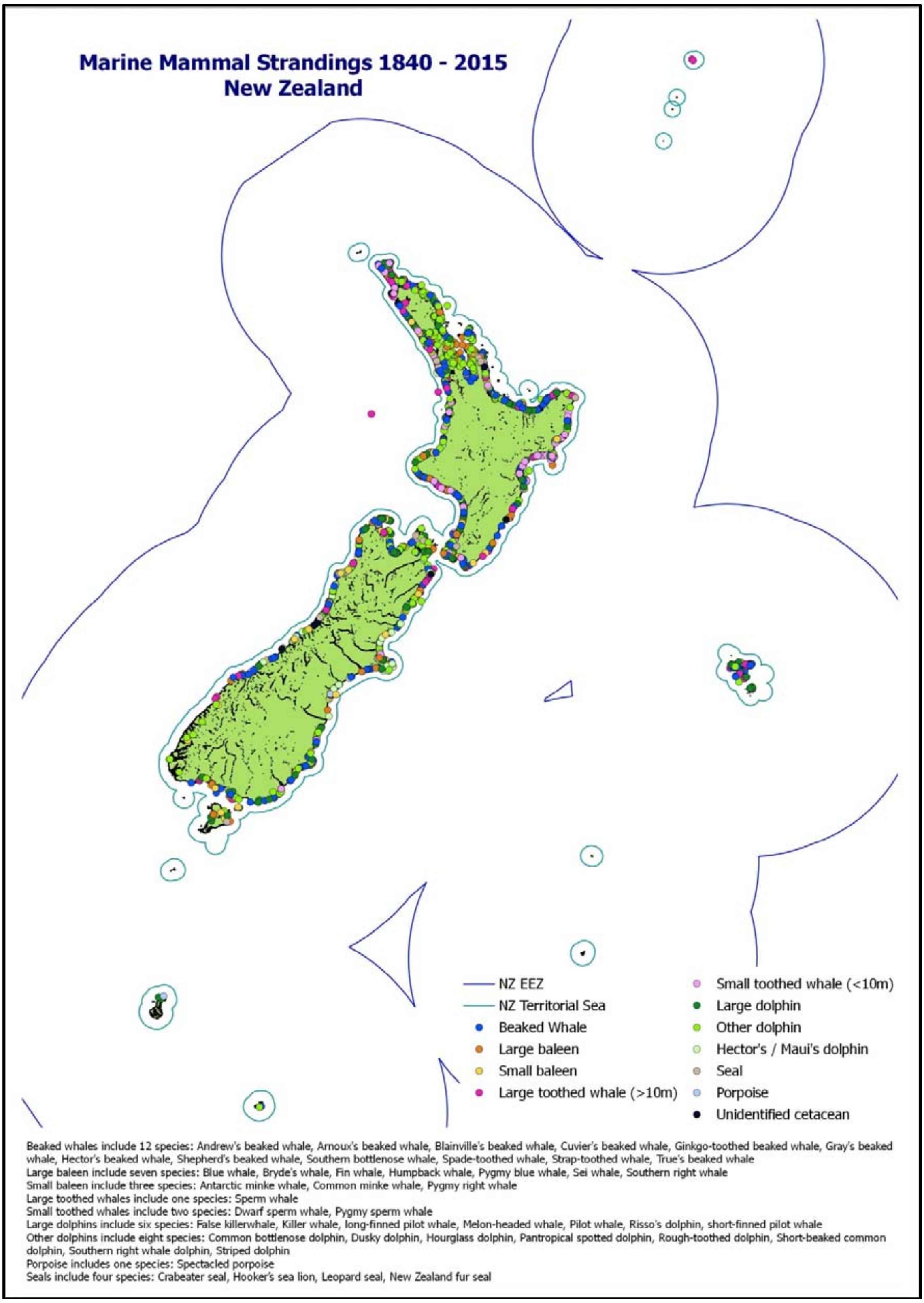
  Species that are represented in the DOC sightings and/or stranding record from the Operational Area and which are classified as 'data deficient' in the New Zealand Threat Classification System.
- **Occasional Visitor**
  Species that are present in the DOC sightings and/or stranding record from the Operational Area, but are listed as 'migrants' in the New Zealand Threat Classification System.
- **Rare Visitor**
  Species that are present in small numbers in the DOC sightings and/or stranding record from the Operational Area or reportedly occur in the Operational Area (source: peer review paper, official reports, personal comment etc.) or whose known range is directly adjacent to the operational area, but are listed as 'vagrants' in the New Zealand Threat Classification System
- **Unlikely**
  Species that are not present in the DOC sightings and/or stranding record from the Operational Area.

Figure 11 Cetacean Sightings in the Vicinity of the Operational Area



Source: DOC sighting database

Figure 12 Summary of Marine Mammal Stranding Around New Zealand



(Source: Department of Conservation, 2015)

Table 8 Cetacean Species Potentially Present in the Operational Area

Species	Scientific name	NZ Threat Status (Baker *et al.* 2016)	Species of Concern?	IUCN Status	Likelihood of Occurrence in Operational Area	Season most likely present
Southern right whale	*Eubalaena australis*	**Nationally vulnerable**	Yes	Least concern	**Likely**	Year round
Pygmy right whale	*Caperea marginata*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Antarctic minke whale	*Balaenoptera bonarensis*	Not threatened	Yes	Data deficient	**Likely**	Year round, except summer
Dwarf minke whale	*Balaenoptera acutorostrata*	Not threatened	Yes	Data deficient	**Possible**	Year round, except summer
Sei whale	*Balaenoptera borealis*	Migrant	Yes	Endangered	Occasional visitor	Year round*
Bryde's whale	*Balaenoptera edeni*	**Nationally critical**	Yes	Data deficient	**Likely**	Summer
Antarctic blue whale	*Balaenoptera musculus intermedia*	Migrant	Yes	Endangered	Occasional visitor	Year round, except summer
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Migrant	Yes	Endangered	Occasional visitor	Year round
Fin whale	*Balaenoptera physalus*	Migrant	Yes	Endangered	Occasional visitor	Year round*
Humpback whale	*Megaptera novaeangliae*	Migrant	Yes	Least concern	Occasional visitor	May – August (northern migration)
Sperm whale	*Physeter Macrocephalus*	Not threatened	Yes	Vulnerable	**Likely**	Year round
Pygmy sperm whale	*Kogia breviceps*	Not threatened	Yes	Data deficient	**Likely**	Year round*
Dwarf sperm whale	*Kogia sima*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Arnoux's beaked whale	*Beradius arnouxi*	Migrant	Yes	Data deficient	Occasional visitor	Year round*
Andrew's beaked whale	*Mesoplodon bowdoini*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Blainville's/dense beaked whale	*Mesoplodon densirostris*	Data deficient	Yes	Data deficient	Unlikely	Year round*
Ginko-toothed whale	*Mesoplodon ginkgodens*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	Yes	Data deficient	**Likely**	Year round*
Hector's beaked whale	*Mesoplodon hectorii*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Strap-toothed whale	*Mesoplodon layardi*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Lesser/pygmy beaked whale	*Mesoplodon peruvianus*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	No	Data deficient	Unlikely	Year round*
Shepherd's beaked whale	*Tasmacetus shepheri*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	Yes	Least concern	Unlikely	Year round*
South Island Hector's dolphin	*Cephalorhynchus hectori hectori*	**Nationally endangered**	Yes	Endangered	Unlikely**	Winter
Common dolphin	*Delphinus delphis*	Not threatened	No	Least concern	**Likely**	Year round
Short-finned pilot whale	*Globicephala macrorhynchus*	Migrant	Yes	Data deficient	Unlikely	Summer
Long-finned pilot whale	*Globicephala melas*	Not threatened	Yes	Data deficient	**Likely**	Year round
Risso's dolphin	*Grampus griseus*	Vagrant	No	Least concern	Rare visitor	Year round*
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	No	Least concern	Unlikely	Year round*
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	No	Data deficient	**Likely**	Year round
Southern right whale dolphin	*Lissodelphis peronii*	Not threatened	Yes	Data deficient	Unlikely	Year round*
Killer whale	*Orcinus orca*	**Nationally critical**	Yes	Data deficient	**Likely**	Year round
False killer whale	*Pseudorca crassidens*	Not threatened	Yes	Data deficient	**Likely**	Year round*
Spotted/Striped dolphin	*Stenella sp.*	Vagrant	No	Least concern	Unlikely	Summer
Rough-toothed dolphin	*Steno bredanensis*	Vagrant	No	Least concern	Unlikely	Year round*
Bottlenose dolphin	*Tursiops truncatus*	**Nationally endangered**	Yes	Least concern	**Likely**	Year round*

** Limited data on which to base seasonality assessment, hence a year round presence has been assumed*

*** Despite a presence in the stranding and sightng record from inshore of the Operational Area, unlikely to be present within the Operational Area on account of its offshore nature*

4.2.4.2 Migration paths through the Operational Area

In general terms, southern hemisphere baleen whales typically migrate south in spring from their tropical breeding grounds to their Antarctic feeding grounds; returning back to the tropics during late autumn-winter for the breeding season (DOC, 2007). The indicative migration paths for humpback, sperm, Bryde's and southern right whales are shown in **Figure 13**. The northern migration routes are relatively well known for some species, however the southwards routes are not. There are exceptions to this general migratory pattern and they are described in the individual species accounts below.

The Pegasus Basin Seismic Survey is expected to take place between November 2016 and June 2017. During this period, the highest densities of most baleen whales are expected at the higher latitude feeding grounds in the Antarctic or the sub-Antarctic. Some southward migration may overlap with any survey activities in October/November; although it is anticipated that the survey will be complete before the northward migration gets underway in late autumn/winter. Overall there is only limited potential for overlap with the migratory behaviours of baleen whales.

Figure 13 Whale Distribution and Migration Pathways in New Zealand Waters

(Source: http://www.teara.govt.nz/en/map/7052/whales-in-new-zealand-waters)

4.2.4.3 Ecological summaries of likely and occasional cetacean species within Operational Area

4.2.4.3.1 Southern right whale

Southern right whales (*Eubalaena australis*) can reach between 15 – 18 m in length. They are slow moving whales, often swimming at speeds less than 9 km/hr, making them vulnerable to ship-strikes. Right whales feed predominantly on zooplankton and tend to 'skim feed' by swimming through swarms of prey with their mouth wide open. This is done either at the surface or at depth (Braham & Rice, 1984).

Southern right whale vocalisations at the subantarctic New Zealand breeding grounds have recently been characterised, with the most frequently recorded vocalisations being 'upcalls', 'pulsive vocalisations' and 'tonal low vocalisations'; with the mean peak frequency of all vocalisations being 264 Hz (range: 43 – 3984 Hz) (Webster *et al.,* 2016).

Under the New Zealand Threat Classification System, southern right whales have recently been downgraded to 'Nationally Vulnerable', with recent data indicate that populations are making a recovery (worldwide, southern right whales are regarded by the IUCN as 'of least concern'). Historic whaling activities through the nineteenth century heavily reduced numbers around NZ: with pre-exploitation abundance estimated to be between 28,800 and 47,100 individuals (Jackson *et al.,* 2016). Following the cessation of this whaling activity only 30–40 mature females were thought to remain (Jackson *et al.*, 2016). Today whale numbers remain low, at an estimated 12% of pre-exploitation abundance (Jackson et al., 2016).

The distribution of southern right whales is strongly influenced by season with most individuals spending summer months feeing at high latitudes (40 – 50°S) (Oshumi & Kasamatsu, 1986) where they take advantage of the seasonal proliferation of their planktonic prey (copepods and euphausiids) (Tormosov *et al.*, 1998; Rowantree *et al.*, 2008). Breeding occurs in winter months when southern right whales move to more temperate lower latitude coastal waters to calve.

Around New Zealand southern right whales occur both in the subantarctic and around the mainland. Genetic evidence suggests that southern right whales present in New Zealand waters are part of a single stock (Carroll et *al.*, 2011) that utilise two breeding grounds. The primary breeding ground is in Port Ross, Auckland Islands (Rayment *et al.*, 2012), with a secondary breeding ground located around mainland New Zealand (Carroll *et al.*, 2011). Southern right whales are the only baleen whale to breed in New Zealand waters, and the coastal waters around mainland New Zealand represent a historic calving ground for this species, with recent evidence suggesting that a slow recolonisation of this range is currently occurring (Patenaude, 2003; Carroll *et al.*, 2011; DOC, 2016). Despite this recolonisation, the number of individual whales utilising winter habitat around the mainland is still believed to be low (Patenaude, 2003). The majority of southern right whale sightings around the New Zealand mainland occur in winter (60%) and spring (22%) with nearly all sightings occurring within a few kilometres of the coast (Patenaude, 2003).

The feeding distribution of southern right whales is less well defined; however, they are believed to disperse widely in offshore waters (Torres *et al.,* 2013). Habitat modelling indicates that this species is likely to utilise areas of high productivity near the subtropical front particularly in autumn (Torres *et al.,* 2011). This is reinforced by the fact that during summer and autumn southern right whales have been observed foraging along the southern edge of the Chatham Rise (Torres *et al.*, 2013).

Thirteen sigthings involving 22 individuals in total have been reported within the Operational Area. In addition to this, southern right whales may feed in the Operational Area (particularly along the southern boundary) during summer and autumn.

Only one stranding incident has been recorded for the species in this vicinity (in Wellington in 2012). Strandings of this species are relatively rare as they are highly adapted to navigate very close to the coast where it is not uncommon for right whales to visit very shallow water (<10 m).

4.2.4.3.2 Pygmy right whale

Little is known of the smallest of the baleen whales, the pygmy right whale (*Caperea marginata*) (Reilly *et al*., 2008; Baker, 1999). The diet is thought to be mainly composed of calanoid copepods (Reilly *et al*., 2008) and euphausiids (Kemper, 2002) but little is known about the acoustic repertoire of this species. A single recording event took palce on a juvenile of the species in Australia. Resulting data identified at least one type of call which was described as a short thump-like pulse with a downsweep in frequency and decaying amplitude (Dawbin & Cato, 1992).

Live sightings of this species are very rare (Reilly *et al*., 2008). Australasian distribution was described by Kemper (2002) as being 32 – 47 °S, with young calves being seen in waters from 35 – 47 °S.

In New Zealand waters, the sightings are mainly recorded near Stewart Island and in the Cook Strait (Kemper, 2002). In 2001 a group of 14 pygmy right whales was seen at 46°S southeast of New Zealand (Matsuoka *et al.,* 2005). The DOC stranding database lists a single stranding of relevance to the Operational Area; in Ohariu Bay in Wellington. This stranding record, together with the habitat preference for offshore deep waters suggest that pygmy right whales are likely to utilise waters in the Operational Area.

4.2.4.3.3 Minke whale

There are two species of minke whale that occur in New Zealand waters: the Antarctic minke whale (*Balaenoptera bonarensis*) and the dwarf minke whale (*Balaenoptera acutorostrata*). These species are difficult to distinguish at sea and records are often combined for both species.

The Antarctic minke is a southern hemisphere species, being very abundant in Antarctic waters in summer. They are commonly seen at lower latitudes in other seasons, although their winter distribution is not well-known (Reilly *et al*., 2008a). The dwarf minke has a wide-spread distribution and occurs over most latitudes in both northern and southern hemispheres. In the southern hemisphere, as with the Antarctic minke, they feed in Antarctic waters in summer with a broader latitudinal distribution in other seasons (Reilly *et al*., 2008a). Outside of summer months, dwarf minkes are thought to occur in shallower coastal water over the continental shelf (Jefferson *et al*., 2008; Perrin, 2009) than their Antarctic counterparts. The population of Antarctic minke whales is thought to number 760,000 in the southern hemisphere; although this population is subject to annual whaling activities in Antarctic waters (Torres *et al.,* 2013).

Minke whales feed on krill, crustaceans and small fish that are caught during short dives (3 – 9 minutes on average). Minke whales produced a variety of vocalisations including low-frequency down sweeps (0.06 – 0.13 kHz), moans and grunts (0.06 – 0.14 kHz), ratchet noises (0.85 – 6 kHz), sweeps and moans (0.06 – 0.14 kHz) and thump trains (0.1 – 2 kHz) (Simmonds *et al*., 2004).

In New Zealand, the DOC sighting and stranding data indicates that the distribution of minke whales (species not distinguished) extends around mainland New Zealand and subantarctic waters; with sightings being reasonably common in spring. A single sighting of minke whale has been recorded in the Operational Area. Seven strandings of minke whales (six Antarctic minke whale strandings and one dwarf minke whale stranding) have occurred in Manawatu and Wellington.

4.2.4.3.4 Sei whale

Sei whales are found worldwide and visit New Zealand waters in summer to feed during their seasonal migrations between the tropics and the southern ocean (Reilly *et al*., 2008b). Unlike other baleen whales they have a slightly more temperate distribution preferring water temperatures of 8 - 18°C (Reilly *et al*., 2008b). Over summer, southern hemisphere populations reside in waters between 45 and 60°S, remaining largely between the subtropical and Antarctic convergences. The winter breeding distributions of sei whales are largely unknown, although it is thought that they return to warmer waters to breed (Te Ara, 2016d). Sei whales are generally found in deep offshore waters (Horwood, 2009).

Sei whales are a fast swimming cetacean whose diet varies with region and season to include copepods, euphausiids, and amphipods (Reilly *et al.*, 2008b). This species of whale commonly feeds at dawn (Shirihai & Jarrett, 2006). The acoustics of sei whales are not well studied. Vocalisations from this species recorded in Antarctic waters included low frequency tonal calls (0.45 ± 0.3 s long and 0.433 ± 0.192 kHz in frequency), frequency swept call and broadband 'growls' or 'wooshes' (Rankin & Barlow, 2007).

Sightings of sei whales around New Zealand occur reasonably infrequently; only two sightings of this species are recorded in the Operational Area in the DOC database. The DOC stranding records include a sei whale stranding on the south coast of Wellington in 1948.

4.2.4.3.5 Bryde's whale

Bryde's whales are typically restricted to tropical and warm-temperate waters, and unlike many other baleen whales probably do not undertake long systematic migrations (Kato, 2002). In general, the latitudinal range of this species is considered to be between 40°N and 40°S (as summarised in Riekkola, 2013).

Bryde's whales in New Zealand are concentrated in northern North Island waters, in particular the Hauraki Gulf which has been identified as an important breeding area (Baker & Madon 2007; Wiseman *et al.*, 2011). Little is known about seasonal latitudinal movements of Bryde's whales in New Zealand. It is likely that a small sub-population of whales regularly use the Hauraki Gulf, but that these individuals are not completely isolated from a larger (but unknown) regional population (Baker *et al.*, 2010). The only systematic investigations of Bryde's whale distribution in New Zealand waters are restricted to the Hauraki Gulf and the east coast of Northland. Opportunistic sighting data is however available for other regions and confirms that Bryde's whales are occasionally sighted off the east coast of New Zealand (Wellington and Canterbury). A single Bryde's whale stranding has been reported from the vicinity of the Operational Area at Whangaehu, Central Hawkes Bay.

Whale species that remain at or near the sea surface for extended periods are particularly vulnerable to ship strike. Bryde's whales in the Hauraki Gulf of New Zealand are known to exhibit such behaviour whereby they spend 90% of their time in the top 12 m of the water column (Constantine *et al.*, 2012). For this reason, ship strike is a major cause of mortality to Bryde's whales near the Port of Auckland (Constantine *et al.*, 2012). Riekkola (2013) investigated potential mitigation measures to reduce the incidence of ship strike to Bryde's whales in Hauraki Gulf and concluded that a reduction in vessel speed (from 13.2 to 10 knots) would effectively reduce the likelihood of lethal injury in any strike incident from 51% to 16%.

Bryde's whale calls are a downward sweep in frequency from 25 to 22 Hz, with an impulsive broadband sound at the start of each call (McDonald, 2010).

4.2.4.3.6 Blue whale

Two subspecies of blue whale occur in New Zealand waters: the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). They are difficult to distinguish at sea, with acoustic characteristics or genetics samples often being required to differentiate (Samaran *et al.*, 2010; Attard *et al.*, 2012). This has resulted in the generic reporting of 'blue whales' in both stranding and sighting data in New Zealand.

Visual or acoustic detections of blue whales have occurred widely through New Zealand waters (Olsen *et al.*, 2013; Miller *et al.*, 2014). They are most commonly heard on the west coast of the North Island, and the east coast of the South Island. Blue whales vocalise at a low frequency (average of 0.01 – 0.110 kHz but some calls have a precursor of 0.4 kHz) (McDonald *et al.*, 2001; Miller *et al.*, 2014) resulting in their vocalisations being able to travel hundreds of kilometres through the water. Their calls can reach levels of up to 188 dB re 1ɥPa m^{-1} (Aroyan *et al.*, 2000; Cummings & Thompson, 1971).

Blue whales depend on krill (euphausiids) as their primary food source. They can be seen lunge feeding on surface swarms of krill or diving to depths of up to 100 m for 10 – 20 minutes; although they are capable of diving to depths of up to 500 m for as long as 50 minutes (Todd, 2014). As blue whales have the highest prey demand of any predator (Rice, 1978; DOC, 2007), large aggregations of food in upwelling areas are extremely important. Worldwide, aggregations of blue whales are known to occur in areas of upwelling that coincide with lower sea surface temperature relative to surrounding waters and high concentrations of euphausiids (Fiedler *et al*., 1998; Burtenshaw *et al*., 2004; Croll *et al*., 2005; Gill *et al*., 2011).

Although outside of the Operational Area, it is noteworthy that a foraging ground for pygmy blue whales has recently been identified in the South Taranaki Bight (Torres *et al*., 2015). Genetic analysis identified blue whales in the Bight as belonging to a distinct haplotype; hence these individuals may comprise a unique population. Sightings of blue whales have been made in all months of the year, suggesting a year-round presence of this population in the region (Torres, 2013; Torres and Klinck 2016). The absolute distribution of blue whales in the Bight changes on a seasonal and year by year basis depending on climatic patterns that drive the distribution of their prey (Torres and Klinck 2016). Observations of mother and calf pairs indicate that this area may also play a role as a nursery area (Torres and Klinck, 2016).

The IUCN Red List of Threatened Species currently lists the Antarctic blue whale as “critically endangered” and the pygmy blue whale as “data deficient”. In contrast, the New Zealand Threat Classification System classifies blue whales as “migrant” and therefore does not designate a threat status; however, blue whales are listed as a “Species of Concern” under the Code of Conduct. In light of the new evidence for blue whale breeding behaviour in the South Taranaki Bight, the New Zealand Threat Classification for blue whales may change in the future.

Little is known about the distribution of blue whales outside of the South Taranaki Bight; however they are often seen travelling northwards through Cook Strait in winter (DOC, 2015). This suggests a presence off the east coast of the South Island in late autumn/winter.

A small number of blue whale sightings have been reported in the Operational Area (off Wellington and in the Cook Strait); and however no strandings have been reported for this species inside the Operational Area.

4.2.4.3.7 Fin whale

Fin whales are found worldwide in primarily offshore waters (Reilly *et al*., 2013). Their summer distribution in the South Pacific is between 50 and 65°S (Miyashita *et al*., 1995) and they are thought to move into warmer, lower latitudes in winter to breed, although their breeding grounds are largely unknown. Although breeding grounds and migration paths are not well documented for this species, they are generally observed in deep offshore waters and are known to occasionally occur in New Zealand waters. Fin whale vocalisations recorded off Great Barrier Island in 1997 indicated a seasonal presence from June to September (McDonald, 2006).

The diet of fin whales varies locally and seasonally. In the southern hemisphere, they feed almost exclusively on krill. However elsewhere, they consume a range of other species, such as fish, squid, krill and other crustaceans (Mizroch *et al*., 1984; Shirihai & Jarrett, 2006).

Fin whales use sound to communicate over large distances. Calls have been described as short (<1 second) down-swept tones, ranging from 28 to 25 Hz at source levels of 189 +/-4dB re 1ɥPa m^{-1} (Širović *et al.,* 2004).

Fin whales have been sighted once in 2014 in offshore waters of the Operational Area. No strandings of this species have been recorded inside the Operational Area.

4.2.4.3.8 Humpback whale

Humpback whales are a migratory species, undertaking the longest migration between feeding and breeding grounds of any mammal (Jackson *et al*., 2014). During summer months, humpbacks feed in Antarctic waters and migrate north to tropical waters for breeding in winter. For the 'Southwest Pacific Ocean' humpback whale population (known as Stock F), this migration route passes through New Zealand waters (Berkenbusch *et al*., 2013), whereby whales move northwards up the east coast of the South Island and through Cook Strait from May to August.

The details of the southern migration (September to November) are less well known, but recent tagging data indicates that individuals travel south well offshore of the east coast of the North Island after stopping off at the Kermadec Islands (NZGeo.com, 2016) (**Figure 14**). The southward migration is thought to be led by the lactating females and yearlings, followed by the immature whales, and lastly the mature males and females. The pregnant females are last to migrate south in late spring (Gibbs & Childerhouse, 2000).

Whales do not forage during their migrations, but depend on stored fat reserves to sustain them though these journeys. On their migrations, humpback whales spend considerable time in coastal regions over the continental shelf (Jefferson *et al*., 2008).

Figure 14 Humpback Whale Southward Migration Routes

Source: NZGeo.com, 2016

Since 2004, DOC has conducted an annual winter survey for humpback whales in Cook Strait with the aim of documenting the recovery of this species through time. The first four surveys ran for two weeks, with those surveys from 2008 onwards running over a full four week period (DOC, 2016a). The number of individual humpbacks seen per year has ranged from 15 (in 2006) to 137 (in 2015). Genetic samples collected during these surveys have been matched to whales in the wider south pacific region, with whales passing through Cook Strait having also been seen off Australia and New Caledonia.

Although both male and female humpbacks produce communication calls, only males emit the long, loud, and complex 'songs' associated with breeding activities. These songs consist of several sounds in a low register, varying in amplitude and frequency, and typically lasting from 10 to 20 minutes (American Cetacean Society, 2016). These songs tend to be between 0.03 – 8 kHz (Simmonds *et al.*, 2004). Other vocalisations of humpback whales include grunts (0.025 – 1.9 kHz), horn blasts (0.41 – 0.42 kHz), moans (0.02 – 1.8 kHz), pulse trains (0.025 – 1.25 kHz), social calls (0.05 – 10 kHz), and shrieks (0.75 – 1.8 kHz) (Simmonds *et al.*, 2004).

Humpback whales are frequently seen in the vicinity of the Operational Area, particularly between the months of May and August on their northern migration. The majority of sightings occur in Cook Strait and off Kaikoura. Sightings have however, been recorded 27 sightings inside the Operational Area the largest of which included 20 animals in Hawke's Bay. Stranded humpback whales have been reported from the coast of Wellington.

4.2.4.3.9 Sperm whale

Sperm whales are the largest of the toothed whale species. They are distributed globally and have a wide geographical and latitudinal distribution. Sperm whales are usually found in open ocean waters deeper than 1,000 m and above the continental slope. Although all whales have significant cultural importance in New Zealand, sperm whales in particular are regarded as chiefly figures of the ocean realm and are commonly recognised as taonga (treasure) to Māori.

Squid is the most common prey of sperm whales, and foraging dives can last over an hour (Evans & Hindell, 2004; Gaskin & Cawthorn, 1967; Gomez-Villota, 2007). During these dives, whales can reach depths of up to 3,000 m. At these depths, the whales become entirely reliant on sound to locate prey and to navigate. To do so, sperm whales produce echolocation clicks which are believed to enable them to determine the direction and distance of prey (Oceanic Research Group, 2016). In addition, sperm whales also use clicks as a means of communication, to identify members of a group and to coordinate foraging activities (Andre & Kamminga, 2000). These clicks are varied in frequency, ranging from low-frequency clicks (0.1 kHz) to high-frequency clicks (up to 30 kHz) (Simmonds *et al.*, 2004). All of these sounds will allow any sperm whales in the proximity to the seismic vessel to be detected by the on-board PAM system.

Detailed descriptions of sperm whale distribution in New Zealand waters are limited to the Kaikoura region where a small number of resident male sperm whales are present year round within a few kilometres of the shore (Jaquet *et al.*, 2000). Many of the Kaikoura sperm whales are semi-resident and return to the area regularly, whilst some are transients that remain further offshore than those considered to be resident (Childerhouse *et al.,* 1995). The average residency time of male sperm whales in the Kaikoura region is 42 days (Lettevall *et al.*, 2002), with daily numbers of animals being lowest in spring when sperm whales tend to leave the area (Sagnol *et al.,* 2015). It is estimated that between 60 and 108 sperm whales are present during any one season (Childerhouse *et al.*, 1995), but that as few as four to five sperm whales are present on average per day (Sagnol *et al.*, 2015). Protection of the population of sperm whales off Kaikoura is of high priority on account of these animals being the focus for a valuable commercial whale-watching industry which uses boats and aircraft to view the animals on a year-round basis (Richter *et al*. 2003).

Sperm whales are frequently seen within the Operational Area. Occasional large groups are reported with a group of 25 seen off eastern Cook Strait during a seismic survey in 2014. Ten sperm whale strandings have occurred along the coast adjacent to the Operational Area since stranding records begun.

4.2.4.3.10 Pygmy sperm whale

Pygmy sperm whales (*Kogia breviceps*) are small whales that are inconspicuous at sea; hence little is known about their biology. Information about preferred diet has been gained from stranded individuals that primarily feed on cephalopods, with a minor component of fish and crustaceans (Beatson, 2007). Little is known of the acoustics of this species; however, data collected from live stranded animals has indicated that the species emits click trains between 60 kHz and 200 kHz (Marten, 2000).

This species occurs in deep offshore water (beyond the edge of the continental shelf) in temperate and tropical waters (Taylor *et al.,* 2012). Strandings of this species are relatively common in New Zealand waters, with 27 strandings of relevance to the Operational Area (one in Manawatu, eight in Hawke's Bay, 18 in Wellington). Hawke's Bay (in particular Mahia Peninsula) is considered to be a hot spot for strandings of this species; they are undoubtedly presence offshore here. Stranding events are largely of single animals; however, the presence of stranded mother/calf pairs is noteworthy from January to April (Baker, 1999). This indicates a summer breeding season for this species in New Zealand waters.

4.2.4.3.11 Beaked whales

Beaked whales are mostly found in small groups in cool, temperate waters with a preference for pelagic deep ocean waters or continental slope habitats at depths down to 3,000 m. They are deep divers and feed predominately on deep-water squid and fish species. Very little is known about the distribution of beaked whales within New Zealand's EEZ. Their preference for deep offshore waters and their elusive behaviour at sea contribute to this paucity of knowledge (Baker, 1999). Eleven species of beaked whales are present in New Zealand; of these, it is considered that the following species are likely to be present in the Operational Area based on stranding records:

<u>Andrew's beaked whale</u>

Andrew's beaked whale (*Mesoplodon bowdoini*) grows to just over 5 m in length (Baker, 1999) and is known from only a few dozen stranding records between 32 and 55°S; well over half of the strandings come from New Zealand (Taylor *et al.,* 2008). Virtually nothing is known about the biology of this whale; however it is presumed to inhabit deep offshore waters and feed primarily on cephalopods like other members of the Mesoplodon genus (Taylor *et al.,* 2008).

Two strandings of this species are of relevance to the Operational Area – both incidents took place along the Manawatu coastline. Strandings of this species in New Zealand occur mostly in spring and summer, and although those strandings of relevance to the Operational Area have not involved calves, mother and calf pairs have stranded in September in other parts of New Zealand, indicating a spring breeding season. Based on the stranding record, the waters around New Zealand are thought to represent a hot spot of concentration for this species (Taylor *et al.,* 2008).

<u>Gray's beaked whale</u>

Gray's beaked whale (*Mesoplodon grayi*) is also known as the scamperdown beaked whale. This species grows to about 5 m in length (Baker, 1999) and is primarily a southern hemisphere cool temperate species with most records occurring from south of 30°S (Taylor *et al.,* 2008a). Little is known about the biology of this whale; however it occurs in deep water beyond the continental shelf and is thought to feed primarily on cephalopods like other members of the Mesoplodon genus (Taylor *et al.,* 2008a).

This species commonly strands on New Zealand's coastline, with ten strandings being of relevance to the Operational Area (all along the Wellington coastline). The Chatham Rise is thought to be a hot spot for this species (Dalebout *et al*., 2004). Calf presence in the stranding record indicates a spring and summer breeding season (Baker, 1999).

Strap-toothed whale

The strap-toothed whale (*Mesoplodon layardii*) grows to just over 6 m in length and is recognisable on account of its two protruding strap-shaped teeth. They are found in cold temperate water from 35 – 60 °S, and typically occur in waters beyond the continental shelf (Taylor *et al.,* 2008b). This species feeds on deep water squid species (Sekiguchi *et al*., 1996).

The DOC stranding record includes 6 incidents of relevance to the Operational Area (all along the Wellington coastline). Most strandings in New Zealand occur between January and April suggesting a seasonal inshore movement during these months (Baker, 1999).

Hector's beaked whale

Hector's beaked whale (*Mesoplodon hectori*) is one of the smallest beaked whales, reaching only 5 m in length (Baker, 1999). This species is found in cool temperate waters of the southern hemisphere (Mead, 1989) and is thought to be relatively common around New Zealand (Taylor et al., 2008c). Little is known about the biology of Hector's beaked whales; however it is presumed to occur in deep water beyond the continental shelf and feed mostly on squid (Taylor *et al.,* 2008c).

A single stranding of this species is of relevance to the Operational Area (a single animal stranded in Wellington). As well as being overall well represented in the New Zealand stranding record, this species also strands in South America, South Africa and southern Australia.

Shepherd's beaked whale

Shepherd's beaked whale (*Tasmacetus shepherdi*) has a stocky body shape and reaches lengths of up to 6 m (Baker 1999). This species appears to be relatively rare, but no abundance estimates are available (Taylor *et al.,* 2008d). It occurs in deep waters well away from coastal habitat, but may approach more closely to land in areas where the continental shelf is narrow (Taylor et al., 2008). Unlike other beaked whales this species feeds primarily on fish, with cephalopods and crustaceans providing minor dietary contributions (Taylor *et al*., 2008d).

A single stranding of this species has been recorded along the coastline adjacent to the Operational Area. No information is available on the breeding biology of this species.

Cuvier's beaked whale

Cuvier's beaked whale (*Ziphius cavirostris*, sometimes also known as the goose-beaked whale) grows up to 7 m in length (Baker, 1999) and is thought to have a global population size of at least 100,000 (Taylor *et al.,* 2008e). They are found through all deep marine biogeographic zones from tropical waters to polar waters in all oceans and are thought to prefer waters close to the continental slope, particularly those with steep bathymetry (Taylor *et al*., 2008e). On account of this habitat preference, this species is not typically associated with coastal zones; however, exceptions have been noted in areas where submarine canyons approach the coast (Heyning, 2002). Cuvier's beaked whales feed predominantly on squid, with some fish and crab contributing a minor component to their diets (MacLeod *et al.,* 2005).

In New Zealand strandings of Cuvier's beaked whales are relatively common, with eight strandings having occurred adjacent to the Operational Area (one in Hawke's Bay and seven in Wellington).

4.2.4.3.12 Hector's dolphin

At only 1.2 – 1.5 m in length New Zealand's endemic Hector's dolphins are one of the smallest cetaceans in the world. There are two subspecies of Hector's dolphin; the South Island Hector's dolphin and the Maui's dolphin. Over the last 40 years, numbers of both subspecies have declined significantly; largely on account of bycatch in coastal fisheries (Currey *et al*., 2012). Maui's dolphin only occurs on the West coast of the North Island, so are of no relevance to the Operational Area.

There are three geographically and genetically distinct sub-populations of South Island Hector's dolphins; of these only the East Coast South Island population is of relevance to the Operational Area. This population extends from Farewell Spit to Nugget Point and is estimated to be comprised of 9,130 individuals (Mackenzie & Clement, 2014). In the top of the South Island, the main concentration of dolphins is found in Clifford and Cloudy Bay, where Hector's dolphins are consistently present, with the highest numbers occurring in summer and autumn (Du Fresne and Mattlin, 2009). A marine mammal sanctuary was established in Clifford and Cloudy Bay in 2008 to protect this species from human threats.

Although primarily coastal in distribution, typically occurring close to shore in turbid waters of under 100 m (Slooten *et al.,* 2006), South Island Hector's dolphins have been recorded out to 20 Nm offshore (MacKenzie & Clement, 2014). Offshore sightings are more common during winter months (Slooten *et al.,* 2006).

Hector's dolphins forage on a range of small fish and crustacean species. Echolocation is used during foraging dives in order to locate prey, with frequencies around 129 kHz (Kyhn *et al*., 2009). Vocalisations are also used for communication in this species.

Thirty two sightings of Hector's dolphins have been recorded in the vicinity of the Operational Area have been made off the east coast of the North Island (Wellington and Wairarapa), and also two historic strandings/entanglements (Wairarapa). Despite this, the vast majority of sightings and strandings are known to occur off the South Island with sightings concentrated inside the 100 m isobath; therefore encounters with Hector's dolphins within the Operational Area itself (which is largely offshore) are considered to be unlikely.

4.2.4.3.13 Common dolphin

Worldwide, there are two species of common dolphin; the short-beaked common dolphin and the long-beaked common dolphin. The short-beaked common dolphin occurs in New Zealand waters, from which they are known to occur in all regions, along the coastline of both the North and South Islands (Berkenbusch *et al.,* 2013). No total abundance estimate is available for the New Zealand population; however, based on the frequency of sightings it is likely that numbers are substantial.

Common dolphins are social animals and often form groups of several thousand individuals. They have been sighted at depths ranging from 6 – 141 m (Constantine & Baker, 1997). In addition, results from the study of stomach contents of common dolphins in New Zealand waters indicates and onshore-offshore diel migration (Meynier *et al.,* 2008). Jack mackerel, anchovy and arrow squid have been found to be the predominant prey species for common dolphins in New Zealand (Meynier *et al.,* 2008).

Common dolphins are known to produce whistles, chirps, barks and clicks. Echolocation click trains are involved in locating prey and navigation whereas whistles are a form of communication. Whistles and chirps vary widely in frequency, ranging from 2-18 kHz and 8-14 kHz, respectively. Barks are relatively low in frequency (<0.5 – 3 kHz) while clicks show the widest variation in frequency from low-frequency clicks of 0.2 kHz to high-frequency clicks of 150 kHz (Simmonds *et al.*, 2004).

Common dolphins are found throughout New Zealand waters, and although they have a propensity for coastal waters, they are common in shallow offshore waters too. Common dolphins are frequently encountered in the Operational Area, with records indicating that this species is most frequently seen off the Wellington coast; however, large groups (approximately 50 dolphins) have also been observed off Hawkes Bay. Twenty eight strandings have been reported for the vicinity of the Operational Area (Hawke's Bay, Manawatu, and Wellington).

4.2.4.3.14 Pilot whales

There are two species of pilot whale worldwide (the long-finned and short-finned) with both species present in New Zealand waters. However, the long-finned pilot whale is more frequently encountered than the short-finned pilot whale (which prefers a slightly warmer subtropical habitat).

Pilot whales are a toothed whale which feed on fish and squid in deep water along shelf breaks. New Zealand studies indicate that pilot whales predominantly feed on cephalopods, usually arrow squid and common octopus (Beatson *et al.,* 2007).

Pilot whales often travel in large groups (over 100 individuals), and have a high stranding rate along the New Zealand coastline. Strandings generally peak in spring and summer months (O'Callaghan *et al.,* 2001), with Farewell Spit at the northwest tip of the South Island, well known for mass whale stranding incidents.

Thirty-five sightings of long-finned pilot whales and eleven sightings of pilot whale sp. are documented in the DOC sightings database for the Operational Area. The largest of these sightigns included 52 individuals and took place in offshore waters east-south-east of the Wellington coastline. A total of 14 stranding incidents of relevance to the Operational Area have involved this species. The two largest sightings involved twenty-two and twenty-three individuals respectively and both took place along the Wellington coastline.

4.2.4.3.15 Dusky dolphin

Dusky dolphins are primarily a coastal dolphin found in water depths less than 2,000 m above the continental shelf and slope. Dusky dolphins are more commonly seen in cooler waters around the South Island and lower North Island (Wursig *et al.,* 2007). The dusky dolphin is present year round in New Zealand waters (Berkenbusch *et al.,* 2013), and Kaikoura supports a substantial population which has been estimated at 12,000 individuals, with approximately 2,000 individuals present at any one time (Markowitz *et al.,* 2004).

Calving is known to occur between December and mid-January (DOC, 2016b), and dusky dolphin groups including calves are frequently recorded in the summer waters around Kaikoura (Wursig *et al.*, 2007).

Little is known about dusky dolphin movements, but photo-identification data confirms that individuals travel up to 1,000 km between locations around the South Island (Wursig *et al.,* 2007). Evidence also suggests that this species spends more time in offshore waters during the winter months (Wursig *et al.*, 2007). Dusky dolphins feed on a range of pelagic and benthic prey species including southern anchovy, squid, hake and lantern fishes (Hammond *et al.*, 2008). They generally forrage in relatively shallow waters, but can dive up to 130 m deep. The dusky dolphin produces echolocation signals, with a low frequency peak at 40-50 kHz and a high frequency peak at 80 to 110 kHz (Au & Wursig, 2004).

Dusky dolphin sightings are reasonably well represented from sightings in the Operational Area. The largest recorded group was of 1,000 individuals in the Cook Strait. Ten strandings have been reported in the regions adjacent to the Operational Area. All incidents involveds single animals.

4.2.4.3.16 Killer whale

Killer whales are the largest member of the dolphin family. They are widespread globally from warm equatorial to cold polar waters. A number of morphological forms of killer whales are recognised (Types A – D) (Baker *et al.*, 2010). The majority of killer whale sightings in New Zealand coastal waters are believed to be Type A, with other types occurring largely in Antarctic waters, but occasionally visiting waters around New Zealand (Visser, 2007). Type A killer whales are classified as 'nationally critical' under the New Zealand Threat Classification System on account of their small population size.

Type A killer whales have been seen in all coastal regions of New Zealand (Visser, 2000). The population size of Type A killer whales in New Zealand was estimated at 115 individuals (95% CI 65–167) in 1997 based on a photo identification catalogue of known individuals (Visser, 2000).

Killer whales are known to echolocate and to produce tonal sounds (whistles). Their whistles have been noted to possess an average dominant frequency of 8.3 kHz and to generally last 1.8 seconds (Thomsen *et al*., 2001). Variations of these whistles (often referred to as dialects) have been documented between pods (Deecke *et al*., 2000). In addition, the use of echolocation has also been demonstrated to vary between groups, depending on the target prey species of a particular group (Barrett-Lennard *et al*., 1996).

New Zealand killer whales are believed to travel an average of 100 – 150 km per day and most groups encountered are opportunistic foragers (Visser, 2000). Around New Zealand this species is wide ranging and highly mobile. This species frequently passes through waters of the Operational Area, with regular sightings from Hawke's Bay, Manawatu and Wellington. A seasonal presence of killer whales around inshore Kaikoura in summer months might reflect an inshore shift in the distribution of dusky dolphins; a known prey item of some killer whales (Visser, 2000). Orca stranding events are not particularly common; however, in the vicinity of the Operational Area; two strandings have been reported for Manawatu and Wellington.

The mobility of this species and their typically opportunistic foraging behaviour indicates that killer whales can readily move between areas to maximise foraging opportunities and avoid disturbance.

4.2.4.3.17 False killer whale

False killer whales are present throughout tropical and warm tropical waters (Baird, 2002). In New Zealand this species has been recorded to form close associations with bottlenose dolphins in shallow waters off north-eastern New Zealand. This distributional shift into shallow waters coincides with the seasonal movement of warm oceanic waters between December and May and reinforces the preference that this species has for warmer waters (Zaeschmaer, 2013).

This species is known to prey on fish and cephalopod species in dives of up to 500 m, occasionally attacking smaller dolphin species (Shirihai and Jarrett, 2006).

There is a single confirmed sighting of this species within the Operational Area. In addition, the strandings database holds three records for this species in the vicinity of the Operational Area (two on the south coast of Wellington; one in Manawatu).

4.2.4.3.18 Bottlenose dolphin

Bottlenose dolphins are widely distributed throughout the world in cold temperate and tropical seas, with New Zealand being the southernmost point of their range. There are three well recognised 'in-shore' populations of bottlenose dolphins in New Zealand; approximately 450 utilise habitat along the northeast coast of Northland, 60 utilise habitat in Fiordland and there is a largely unquantified population living in the coastal waters between the Marlborough Sounds and the West Coast. There appears to be little or no gene flow between the three in-shore populations (Baker *et al*., 2010). In addition to the inshore populations, bottlenose dolphin sightings are common in offshore waters right around New Zealand where estimates suggest an 'offshore' population size of at least 163 individuals (Zaeschmar *et al*., 2013). These offshore dolphins are typically seen in larger groups than the inshore dolphins (Torres, 2012).

Bottlenose dolphins feed on fish, krill and crustaceans and are known to feed cooperatively (Shirihai & Jarrett, 2006). Bottlenose dolphins produce 'clicks' which are used for echolocation purposes (0.8-24 kHz) and 'whistles' which are used as a form of communication (40 – 130 kHz).

Sightings of bottlenose dolphins occur reasonably frequently in Wellington. With the exception of a lone bottlenose dolphin dubbed 'Moko' who was resident around Mahia Peninsula from 2007 to 2010 (Carpinter & Joyce, 2010), no other sightings are recorded from Hawke's Bay. Three strandings however have been reported from the Wellington coastline.

4.2.5 Pinnipeds

Nine species of pinnipeds are known from New Zealand waters. Of these only the New Zealand fur seal and Southern elephant seal is 'likely' to occur in the Operational Area; leopard seals could occur as 'rare visitors' as both have occasionally been reported from locations adjacent to the Operational Area on the east coast of New Zealand.

4.2.5.1 NZ Fur Seal

New Zealand fur seals are native to New Zealand and Australia and have a wide distribution around mainland New Zealand and its offshore islands. On mainland New Zealand, breeding colonies are mostly located in the South Island. Commercial sealing ceased in 1894, and this species has subsequently been undergoing a recolonisation of its historic range, with an increase in population size and an expansion northwards of its breeding distribution (Lalas & Bradshaw, 2001). A reliable total abundance estimate is not available for this species, but estimates in the vicinity of 100,000 individuals have been suggested (Harcourt, 2001).

New Zealand fur seals often forage along continental shelf breaks, but foraging habitat varies with season whereby both inshore and deeper offshore foraging habitat is used throughout the year (Harcourt *et al*., 2002; Mattlin *et al*., 1998). They are known to dive for up to 12 minutes (~ 200 m) (Mattlin *et al*., 1998) to feed on fish (e.g. lantern fish, hoki, barracouta, ahuru and jack mackerel,) and cephalopods (arrow squid and octopus) (as summarised by Baird, 2011).

The breeding season for New Zealand fur seals extends from mid-November to mid-January, with peak pupping occurring in mid-December (Crawley & Wilson, 1976). Pups are suckled for approximately 300 days, during which females will alternate between foraging at sea and returning to the rookery to feed their young (Boren, 2005). Inshore of the Operational Area the most important breeding colonies for this species are Cape Palliser (Greater Wellington) and Ohau Point (Kaikoura) (Arnold, 2003). The Ohau Point colony was found to be growing exponentially during the breeding seasons 2002 – 2005 with approximately 600 pups produced in 2005 (Boren, 2005). In 2011, an estimated 1,508 pups were produced (Baird, 2011). Equivalent population data is unavailable for Cape Palliser; however, the last pup count in 1999 estimated an annual pup production of 40 – 50 pups (Baird, 2011). The shelf edge has been recognised as being valuable to this species as foraging habitat (Arnold, 2003). New Zealand fur seals will be consistently present in the Operational Area.

4.2.5.2 Southern elephant seal

The southern elephant seal is the largest species of seal in the world, with adult males reaching 3,500 kg. The species range covers the Southern Ocean and most islands of the subantarctic. The NZ population congregates in breeding colonies on the Antipodes Island and on Campbell Island between May and November, and during the winter months, these animals will frequently visit the Auckland and Snare Islands (DOC, 2016k). Elephant seals feed mainly on deepwater fish and cephalopods which they catch during deep dives which last up to 20 minutes. Rest intervals between dives are typically short, resulting in these animals being elusive at sea (Shirihai & Jarrett, 2006). The southern elephant seal is classified as "least concern" by the IUCN red list; however, there has been a 5-11% decline in animals at breeding colonies over the past few years. This species is classified as "nationally critical" in NZ. There are three sightings in the DOC sighting database of this species within the Operational Area so it is likely that this species frequents the Operational Area.

4.2.6 Marine Reptiles

The DOC Atlas of Amphibians and Reptiles (DOC, 2016c) contains distribution information for marine reptiles (turtles, sea snakes, and kraits) that have been recorded in New Zealand waters. Since records began there have been eight species of marine reptiles recorded in New Zealand waters; the loggerhead turtle, the green turtle, the hawksbill turtle, the olive Ridley turtle, the leatherback turtle, the yellow-bellied sea snake, common sea krait and the banded sea krait (DOC, 2016c). Apart from the leatherback turtles, marine reptiles are generally found in warm temperate waters and as a result most of NZ's marine reptiles are found off the northeast coast of the North Island.

All of the marine reptiles that have been recorded in New Zealand waters have been recorded in the Operational Area with the exception of the common sea krait (DOC, 2016c). Marine reptiles are rare visitors to New Zealand waters and the Operational Area is not a marine reptile hotspot, therefore marine reptiles are unlikely to be present during seismic operations.

4.2.7 Seabirds

New Zealand supports the most diverse seabird community in the world, with a total of 96 taxa found in New Zealand's marine waters (Taylor, 2000). As a result of this high diversity, New Zealand is often referred to as the 'Seabird Capital of the World' (DOC, 2016d). Seabirds present in New Zealand include albatross, cormorants/shags, fulmars, petrels, prions, shearwaters, terns, gulls, penguins, and skuas.

New Zealand's east coast supports a large diversity of seabirds that either pass through or utilize the area as a foraging, breeding, and/or resting location; however, the importance of the Operational Area to seabirds is largely unknown. Many of the species present in the Operational Area are likely to be reasonably coastal in their distributions, such as penguins, shags, gulls and terns. However, a number of pelagic species such as albatross, shearwaters, and petrels utilize the offshore waters of New Zealand's east coast. In addition, gulls and terns can extend their distribution to more offshore areas.

A number of references, i.e. Scofield and Stephenson (2013), Robertson *et al.* (2013) and NZ Birds Online (2016) have been used to identify the birds that are likely to be observed in the Operational Area. A summary of these species is present in **Table 9** below. In general there have been no systematic and quantitative surveys on seabird occurrence; therefore **Table 9** is based on observational presence/absence data.

Of the 84 seabird species that breed in New Zealand, 43% (35 species) are endemic breeders (Taylor, 2000). A number of sites along New Zealand's east coast are of significant breeding value to seabirds. Species known to breed along the coastline adjacent to the Operational Area have been identified in **Table 9**.

Table 9 Seabirds Potentially Present Within the Operational Area

Common Name	**Scientific Name**	**Breeding season**	**Breeds Adjacent to Operation Area**	**IUCN Status** www.redlist.org	**NZ Threat Status** Robertson *et al.*, 2013
Antipodean albatross	*Diomedea antipodensis antipodensis*	All year	×	Not yet assessed	Nationally Critical
Black-billed gull	*Larus bulleri*	Aug – Mar	×	Endangered	Nationally Critical
Chatham Island taiko	*Pterodroma magentae*	Nov – Jun	Chatham Island	Critically Engangered	Nationally Critical
Gibson's albatross	*Diomedea antipodensis gibsoni*	All year	×	Not yet assessed	Nationally Critical

Common Name	Scientific Name	Breeding season	Breeds Adjacent to Operation Area	IUCN Status www.redlist.org	NZ Threat Status Robertson *et al.*, 2013
Salvin's mollymawk	*Thalassarche salvini*	Sep – Apr	×	Vulnerable	Nationally Critical
Black-fronted tern	*Chlidonias albostriatus*	Oct – Jan	×	Endangered	Nationally Endangered
Black petrel	*Procellaria parkinsoni*	Oct – Jul	×	Vulnerable	Nationally Vulnerable
Caspian tern	*Hydroprogne caspia*	Sep – Jan	Possible	Least Concern	Nationally Vulnerable
Chatham petrel	*Pterodroma axillaris*	Nov – Jun	Chatham Islands	Vulnerable	Nationally Vulnerable
Flesh-footed shearwater	*Puffinus carneipes*	Sep – May	✓	Least Concern	Nationally Vulnerable
Little black shag	*Phalacrocorax sulcirostris*	Oct – Dec	✓	Least Concern	Nationally Vulnerable
Pied shag	*Phalacrocorax varius varius*	All year	✓	Not yet assessed	Nationally Vulnerable
Red-billed gull	*Larus scopulinus*	Sep – Jan	✓	Least Concern	Nationally Vulnerable
Hutton's shearwater	*Puffinus huttoni*	Oct – Mar	✓	Endangered	Declining
Light-mantled sooty albatross	*Phoebetria palpebrata*	Sep – Jun	×	Near Threatened	Declining
Little penguin	*Eudyptula minor*	Jul – Feb	✓	Least Concern	Declining
Sooty shearwater	*Puffinus griseus*	Nov – May	✓	Near Threatened	Declining
White-capped mollymawk	*Thalassarche cauta steadi*	Nov – Aug	×	Not yet assessed	Declining
White-chinned petrel	*Procellaria aequinoctialis*	Nov – May	×	Vulnerable	Declining
White-fronted tern	*Sterna striata*	Oct – Jan	Possible	Least Concern	Declining
Little shearwater	*Puffinus assimilis*	Apr – Nov	×	Least Concern	Recovering
Broad-billed prion	*Pachyptila vittata*	Aug – Jan	×	Least Concern	Relict
Cook's petrel	*Pterodroma cookii*	Sep – Apr	×	Vulnerable	Relict
Fairy prion	*Pachyptila turtur*	Oct – Feb	✓	Least Concern	Relict
Fluttering shearwater	*Puffinus gavia*	Aug – Jan	✓	Least Concern	Relict
Grey-backed storm petrel	*Garrodia nereis*	Sep – Apr	×	Least Concern	Relict
Mottled petrel	*Pterodroma inexpectata*	Dec – May	×	Near Threatened	Relict
Northern diving petrel	*Pelecanoides urinatrix urinatrix*	Aug – Dec	✓	Not yet assessed	Relict
White-faced storm petrel	*Pelagodroma marina maoriana*	Oct - Apr	✓	Least Concern	Relict

Common Name	**Scientific Name**	**Breeding season**	**Breeds Adjacent to Operation Area**	**IUCN Status** www.redlist.org	**NZ Threat Status** Robertson *et al.*, 2013
Antarctic Prion	*Pachyptila desolata*	Dec - Apr	×	Least Concern	Naturally Uncommon
Black shag/Great cormorant	*Phalacrocorax carbo*	All year	Possible	Least Concern	Naturally Uncommon
Brown skua	*Catharacta Antarctica*	Sep – Feb	×	Least Concern	Naturally Uncommon
Buller's mollymawk	*Thalassarche bulleri bulleri*	Oct – Jun	×	Not yet assessed	Naturally Uncommon
Buller's shearwater	*Puffinus bulleri*	Sep – May	×	Vulnerable	Naturally Uncommon
Campbell mollymawk	*Thalassarche impavida*	Aug – May	×	Vulnerable	Naturally Uncommon
Cape petrel	*Daption capense capense*	Nov – Feb	×	Not yet assessed	Naturally Uncommon
Chatham island mollymawk	*Thalassarche eremita*	Aug – May	×	Not yet assessed	Naturally Uncommon
Grey petrel	*Procellaria cinerea*	Apr – Nov	×	Near Threatened	Naturally Uncommon
Northern giant petrel	*Macronectes halli*	Aug – Feb	×	Least Concern	Naturally Uncommon
Northern royal albatross	*Diomedea sanfordi*	All year – eggs laid in Oct/Nov	×	Endangered	Naturally Uncommon
Snare's cape petrel	*Daption capense australe*	Nov – Feb	×	Not yet assessed	Naturally Uncommon
Southern royal albatross	*Diomedea epomophora*	All year – eggs laid in Nov/Dec	×	Vulnerable	Naturally Uncommon
Spotted shag	*Stictocarbo punctatus*	All year	✓	Least Concern	Naturally Uncommon
Westland petrel	*Procellaria westlandica*	Mar – Dec	×	Vulnerable	Naturally Uncommon
Arctic tern	*Sterna paradisaea*	Does not breed in NZ		Least Concern	Migrant
Little tern	*Sternula albifrons sinensis*	Does not breed in NZ		Not yet assessed	Migrant
Short-tailed shearwater	*Puffinus tenuirostris*	Does not breed in NZ		Least Concern	Migrant
Snowy albatross	*Diomedea exulans*	Does not breed in NZ		Vulnerable	Migrant
Southern giant petrel	*Macronectes giganteus*	Does not breed in NZ		Least Concern	Migrant
White-winged black tern	*Chlidonias leucopterus*	Does not breed in NZ		Least Concern	Migrant
Wilson's storm petrel	*Oceanites oceanicus*	Nov – Apr	×	Least Concern	Migrant
Black-browed mollymawk	*Thalassarche melanophris*	Sep – May	×	Near Threatened	Coloniser

Common Name	Scientific Name	Breeding season	Breeds Adjacent to Operation Area	IUCN Status www.redlist.org	NZ Threat Status Robertson *et al.*, 2013
Indian ocean yellow-nosed mollymawk	*Thalassarche carteri*	Eggs laid in Sep – Oct	×	Endangered	Coloniser
Soft-plumaged petrel	*Pterodroma mollis*	Sep – May	×	Least Concern	Coloniser
Australasian gannet	*Morus serrator*	Aug – Mar	✓	Least Concern	Not Threatened
Black-bellied storm petrel	*Fregetta tropica*	Nov – May	×	Least Concern	Not Threatened
Black-winged petrel	*Pterodroma nigripennis*	Oct - May	×	Least Concern	Not Threatened
Grey-faced petrel	*Pterodroma gouldi*	Mar – Jan	×	Least Concern	Not Threatened
Little pied shag	*Phalacrocorax melanoleucos brevirostris*	Aug – Mar	✓	Not yet assessed	Not Threatened
Southern black-backed gull	*Larus dominicanus dominicanus*	Sep – Mar	✓	Not yet assessed	Not Threatened
White-headed petrel	*Pterodroma lessonii*	Nov – Jun	×	Least Concern	Not Threatened

4.3 Protected Areas

4.3.1 Regional Coastal Environment

The Operational Area extends from Napier in the North Island, south to Kaikoura on the South Island. The Coastal Marine Area (CMA) inshore of the Operational Area is under the jurisdiction of the following regional authorities; Hawke's Bay Regional Council, Horizons Regional Council, Greater Wellington Regional Council, Marlborough District Council, and Environment Canterbury. The following information is a brief overview of the coastal environment within each region.

4.3.1.1 Hawke's Bay Coast

Hawke's Bay Regional Council have jurisdiction over 353 km of coastline from Mahia Peninsula and Mahanga in the north, south to approximately Porangahau Beach. This region is characterised by a range of coastal habitats and environments including lagoons, bar-built river mouths, estuaries, intertidal rocky reef platforms, gravel and sand beaches, dune fields, subtidal rocky reefs, and subtidal soft sediment habitats (Haggitt & Wade, 2016). Coastal features between Cape Kidnappers and Cape Turnagain in the south of the region are typical of a more exposed coastline; large undulating coastal cliffs, sandy beaches, extensive dune systems and rock platforms (HBRC. 2014). A large proportion of the Hawke's Bay coast has been extensively modified in order to accommodate the expansion of Napier and Hastings and to allow for increased farming and horticulture (Haggitt & Wade, 2016).

4.3.1.2 Horizons Coast

Horizons Regional Council have jurisdiction over a 40 km stretch of coastline on the North Island's east coast. This stretch is coastline is characterised by wave-swept rocky platforms that are backed by beaches comprised of boulders/cobbles or sandy beaches dotted with boulders. Numerous rock pools can be found on the rocky platforms. These pools are broad and shallow, usually with sandy bottoms and high densities of seaweeds. Between the pools are patches of coralline algae, Neptune's necklace seaweed and occasional patches of seagrass growing on sand. The river mouths in the Horizons Region usually form large alluvial flats that enter the sea as sandy bays. Canyons and banks are absent from the continental slope, with the nearest major submarine feature the Madden Depression 10 km off the Porangahau River Mouth (HRC, 2014).

4.3.1.3 East and South Wellington Coast

The Wellington coast contains a range of shorelines including dune backed open sandy beaches, boulder, cobble and gravel beaches, wave-cut rocky platforms, steep cliffs, and river mouths with sandy bays and spits. The east and south coasts are exposed to strong prevailing winds, resulting in high energy coastal environments (Kettles & Hughes, 2009).

Wellington's south coast (to the west of Wellington Harbour) is made up of steeply sloping rock headlands that consist mainly of exposed rocky reefs interspersed with coarse sand beaches. A number of offshore reef systems extend from the intertidal to depths of more than 30 m. Although this coastline is directly exposed to prevailing southerly storms, most of the rocky platforms are relatively protected by the offshore submerged rocks and reefs. This coast contains a highly diverse algae community (Kettles & Hughes, 2009).

The coastline within Wellington Harbour, while highly modified, contains a variety of habitats that range from exposed rocky reefs at the harbour entrance to a sheltered estuary at the Hutt River Mouth. Narrow rocky intertidal platforms are found throughout the Harbour, and are interspersed with sandy beaches (Kettles & Hughes, 2009).

The coastline from Eastbourne to Turakirae Head lies on the exposed coast to the east of Wellington Harbour. A number of small sediment filled bays are located in this coastal section, which are comprised mainly of boulders and cobbles. Rocky headlands separate these stony beaches (Kettles & Hughes, 2009).

Turakirae Head to Thrust Creek lies on the exposed southeast coast. This section of coastline is a geologically active raised beach system that is characterised by rocky outcrops, and cobble and boulder beaches (Kettles & Hughes, 2009).

Palliser Bay lies on the southeast coast of the Wellington Region. This area is predominantly comprised of coarse alluvial sand, gravel and cobble beaches. Offshore reefs, rock outcrops, and raised marine terraces (up to 250 m above sea level) are located on the eastern side of Palliser Bay. Lake Onoke backs Palliser Bay. This lake is a brackish barrier spit lagoon that is highly exposed to the south and south-east. Bull kelp is a feature of the rock outcrops and reefs of Palliser Bay (Kettles & Hughes, 2009).

The Wairarapa coastline in the north of the Wellington region is highly exposed and contains steep cliffs and rocky platforms interspersed. These rock platforms are interspersed with gravel and sand beaches further north, and large areas of dunes are found at Uruti and Flat points. Limestone cliffs are found at Castle Point and Cape Turnagain. A large estuary and widening of mixed sand and mud substrate is found off the Owahanga River Mouth while alternating eroded mudstone and siltstone tongue and groove shore platforms lie between Omaruapakihau and Mataikona. Northern intertidal reefs are generally more extensive and contain a higher diversity than those to the south. Surge channels and rock pools characterise the lower shore (Kettles & Hughes, 2009).

4.3.1.4 South Marlborough Coast

The coastal marine environment on Marlborough's south coast is extremely diverse as a result of a range of environmental gradients across the region such as wave exposure, temperature, substrate, water depth, tidal influence, sedimentation, and productivity (Bentley et al., 2014). In general, the coast south of the Marlborough Sounds is exposed to strong wave action and cold turbid waters, with a wide continental shelf and long sand and gravel beaches that are interrupted by nearshore reefs (Bentley *et al.,* 2014). The South Marlborough coast is bordered offshore by the deep Hikurangi Canyon. Bentley *et al.* (2014) further divides the Marlborough coast south of the Marlborough Sounds into two marine areas; the Clifford and Cloudy Bay marine area and Cape Campbell to Willawa Point marine area, as described below.

The upper South Marlborough coast is dominated by the large, exposed and open Clifford and Cloudy Bays. Within these bays are two large estuary systems; Wairau Estuary in Cloudy Bay and Lake Grassmere in Clifford Bay. High winds, swells and currents shape this coastline, with Cape Campbell providing some shelter further south. The waters along this coastline are typically cold, nutrient-rich and high in turbidity. The outer coastline and immediate subtidal zone is made up mainly of mixed sand and gravel beaches, with the offshore areas comprised of mainly silty sand grading into gravel. The sand/gravel beaches support a relatively low diversity and abundance of marine life; mainly surf clams in the nearshore sediments with shellfish and mobile invertebrates further offshore in the more stable sand, silt and gravel substrates. The highest diversity is found in the shelter of Cape Campbell, with species including limpets, chitons, topshells, mussels, barnacles and seaweeds. More offshore reefs are higher in animal and plant diversity than closer to shore, with encrusting sponges, ascidians and bryozoans particularly dominant (Bentley et al., 2014).

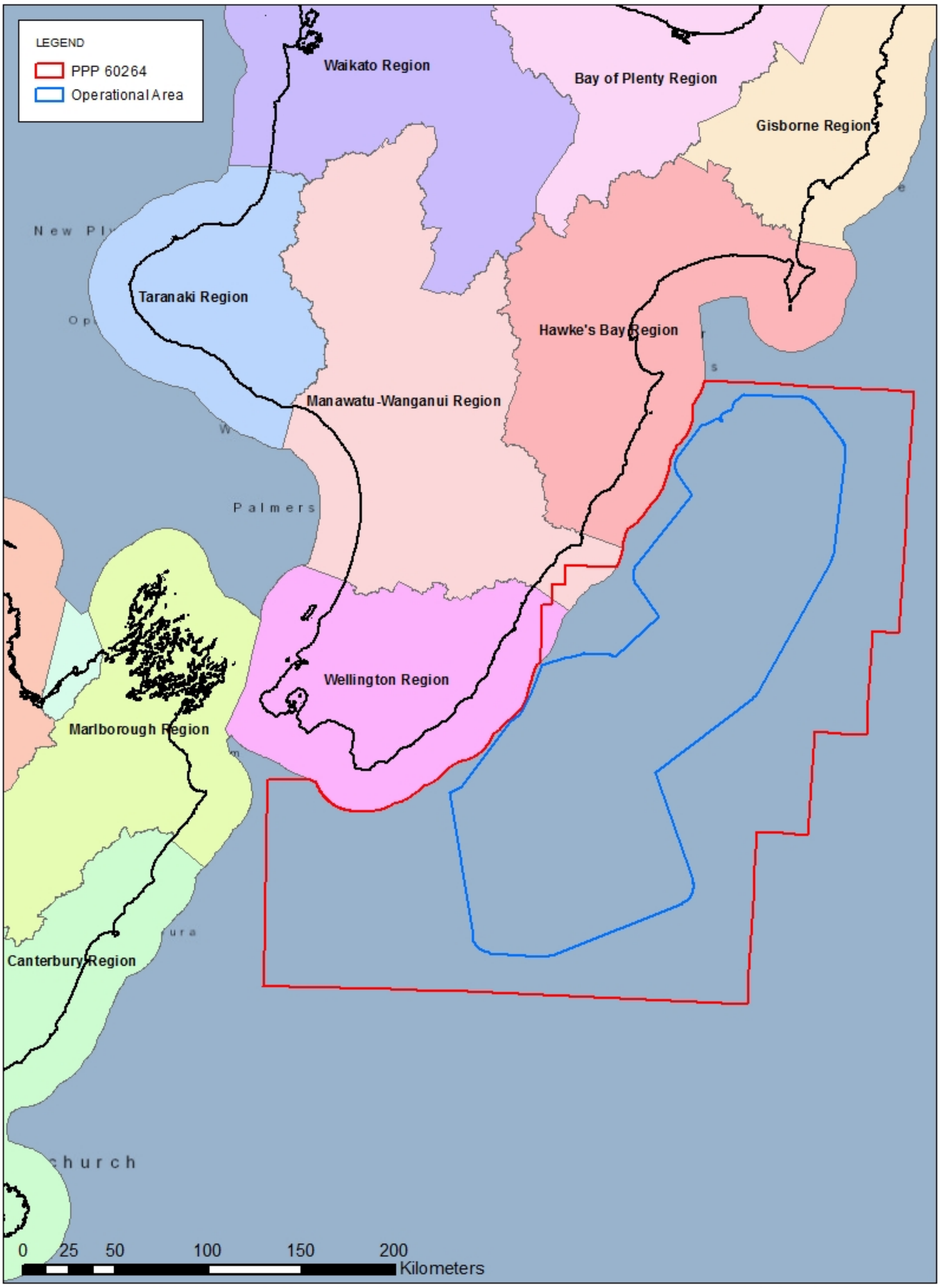
The coastline south of Cape Campbell is relatively straight and highly exposed to southerly and easterly storms. As a result, high turbidity and low water clarity are features of this coastline. The depth gradient along this coast is steep, dropping to 100 m water depth within 6 km from the shoreline. Sand and gravel beaches are the dominant substrate type; however, rocky headlands, platforms, outcrops and reefs also commonly occur. The sand and gravel beaches support a low diversity and abundance of marine life while the intertidal platforms and reefs support communities typical of exposed coasts. Large offshore beds of giant kelp can also be found.

4.3.1.5 Canterbury Coast

Environment Canterbury have jurisdiction over nearly 800 km of coastline form Kekerengui Point in the north, south to the Waitaki River. This stretch of coastline is further divided into nine geographical areas, with one of relevance to the Operational Area; the Kaikoura Area (ECan, 2005).

The Kaikoura area is influenced by sea conditions which are often rough. The mudstone and folded limestone (Marsden & Schiel, 2007) cliff and rock headlands of the Kaikoura Peninsula is a distinctive feature of this coastline (ECan, 2005). The east-facing coast close to the Kaikoura Peninsula consists of long gravel beaches, boulder beaches, rocky shores and platforms. Narrow and steep dynamic mixed gravel and sand beaches dominate the remainder of this coast. Although rare, sand beaches are also present, mainly in small inlets on the Peninsula. Due to the lack of sheltered mud-filled inlets estuaries are not well developed on this coastline (Marsden & Schiel, 2007). Site plays a large role in determining the species present; however, in general molluscs are most abundant on rocky shores while mobile crustaceans dominate the gravel beaches (Marsden & Schiel, 2007).

Figure 15 Regional Council Boundaries in Relation to the Operational Area



4.3.1.6 Hawkes Bay Regional Council Significant Conservation Areas

The Hawke's Bay Regional Council identifies a number of sites within their Regional Coastal Environment Plan as Significant Conservation Areas (HBRC, 2014). These areas are provided in **Table 10** below and have been identified based on criteria such as cultural values, presence of protected areas, presence of wetlands, estuaries and coastal lagoons, the habitats and environmental services provided (e.g. presence of roosting, breeding and feeding sites), their scenic values, historic values, and presence of representative or outstanding coastal landforms and associated processes.

It is important to note that iwi of Ngati Kahungunu consider the entire Coastal Marine Area within Hawke's Bay to be of significance to Maori, therefore in addition to the values listed below, all of the Significant Conservation Areas also have high cultural values.

Table 10 Hawkes Bay Regional Council Significant Conservation Areas

Site	Values
Porangahau Estuary	This estuary is the largest and least modified on the North Island's east coast. It is rich in archaeological sites (shell middens) and provided the first authenticated records of moa hunter in the North Island. The estuary and offshore area are subject to a taiapure application and Taikura Rocks are waahi tapu (a sacred site). The estuary is an important source of flatfish, kahawai, eels and whitebait. It provides important feeding and wintering areas for migratory waders and contains the largest concentrations of wrybill and banded dotterel in Hawke's Bay. Significant numbers of migratory bar-tailed godwit and knot use the estuary. This site is considered a wetland of national importance to fisheries and a nationally significant wildlife habitat, the dune system to the north of the estuary has a national priority rating for conservation, and the bar at the mouth of the estuary is a regionally significant coastal landform.
Blackhead Point – Pohatupapa Point Intertidal Platform	The intertidal rock platforms and nearshore reef systems represent important traditional fisheries to tangata whenua. The coast was heavily populated by Maori with at least three coastal pa between Porangahau Estuary and Blackhead Beach. Wildlife values at this site are high; the platforms provide feeding habitat for at least 15 native bird species. The platforms are particularly important for white-faced heron, variable oystercatcher, red-billed gull, eastern bar-tailed godwit, black shag, and white-fronted tern. Extensive sea grass beds and *Hormosira banksii* turfs in the mid to low tidal zone support biologically diverse intertidal communities.
Aramoana – Blackhead Beach	This site covers all foreshore, seabed and tidal waters below MHWS within 1 Nm of the shore and includes the intertidal platforms at Te Angaiani Marine Reserve. Wildlife values at this site are high with feeding habitat provided for at least 15 species of native bird; the platforms are particularly important for white-faced heron, variable oystercatcher, red-billed gull, eastern bar-tailed godwit, black shag, and white-fronted tern. Extensive sea grass beds and *Hormosira banksii* turfs in the mid to low tidal zone support biologically diverse intertidal communities. The seaward face of the intertidal platform at this site is generally steep and densely covered in large brown seaweeds. At least 150 subtidal species have been recorded within the Marine Reserve.

Ouepoto – Paoanui Point	This site includes two intertidal rock platforms separated by a sandy beach and a large inshore reef system (Charity Reef). The intertidal platforms and nearshore reef system are important traditional fishing grounds, with a number of pa present along the coastal prior to European settlement. Wildlife values at this site are very high; the platforms provide feeding habitat for at least 15 native bird species. Extensive sea grass beds and *Hormosira banksii* turfs in the mid to low tidal zone support biologically diverse intertidal communities; 85 – 100 plant, invertebrate and fish species have been recorded at each platform. Charity Reef supports a variety of species characteristics of inshore reefs in Central Hawke's Bay and forms a major part of a regionally significant commercial rock lobster fishery. This site has high historic values; Captain Cook anchored the Resolution and received two local chiefs aboard and the first sheep station in Hawke's Bay was also established at this site. Paoanui Point is also a nationally important fossil location.
Mangakuri Intertidal Platform	This platform and nearshore reef system represents important traditional Maori fisheries, with the adjacent coast heavily populated by Maori prior to European settlement. Wildlife values at this site are very high, with the platform providing feeding habitat for at least 15 native bird species; the platforms are particularly important for white-faced heron, variable oystercatcher, red-billed gull, eastern bar-tailed godwit, black shag, and white-fronted tern. This platform is covered with boulders and barely elevated above low water and lacking the *Hormosira banksii* dominated flats in the mid to low tidal zone. Extensive sea grass beds cover the upper parts of the platform while large brown algae dominate the underwater sections.
Kairakau Intertidal Platform	This site is the last in the series of intertidal platforms in Hawke's Bay. This platform and nearshore reef system represents important traditional Maori fisheries, with the adjacent coast heavily populated by Maori prior to European settlement. Wildlife values at this site are very high, with the platform providing feeding habitat for at least 15 native bird species. A feature of this site is the presence of large, deep rock pools and channels, with the intertidal dominated by sea grasses and the pools and channels dominated by large brown algae.
Hinemahanga Rocks	Hinemahanga Rocks represent part of a once continuous sheet of Mid Oceanic Ridge basalts that are being subducted beneath Upper Cretaceous sediments and as a result are considered a nationally significant geological site.
Waimarama	This site includes Motu-O-Kura (Bare Island), extensive subtidal reef systems, sandy beach, isolated reefs, an intertidal platform and large areas of sandy seafloor. The importance of this site as a traditional fishing ground is recognised by the Waimarama Fishing Reserve. Motu-O-Kura is the only true island between Wairoa and Wellington. It is rat free and supports nesting of little penguins, sooty shearwater, black shag, and black-backed gulls. The island is also a hauling ground for fur seals (18 – 20 animals); the only colony in the Hawke's Bay Region. This site is regionally significant due to the variety of marine habitats present and is also a nationally important geological site.
Cape Kidnappers (Clifton – Ocean Beach)	Cape Kidnappers is the most prominent landscape feature in southern Hawke's Bay. This site has high Maori cultural values; archaeological sites along the coast date back to the Moa-hunter period and include numerous pa, urupa (burial sites), middens and find sites. A track once crossed Cape Kidnappers that linked southern coastal communities to those in Hawke's Bay. The intertidal and near shore reefs remain important sources for kiamoana. This site includes a number of protected areas; Black Reef and Saddle gannet colonies are Nature Reserves and the Plateau colony is a Government Purpose Reserve. Gannet colonies at this site represent some of the World's most accessible gannet colonies. Cape Kidnappers is considered an internationally significant seabird habitat; white-fronted terns also nest along the cliffs at Black Reef and the reef itself is one of few roost sites for spotted shag in Hawke's Bay. The scenic and geological values at this site are classed as internationally significant. Cape Kidnappers is valued for its historic values, and coastal landforms and associated processes.

Tukituki River Mouth	This river mouth was the location of three pa sites, with the estuary and offshore area supporting traditional fisheries for kahawai, flatfish, whitebait, and smelt. The estuary and backwaters have been recommended for protection based on high wildlife values. The estuary is an important feeding area for shags and the river mouth bar is the main roost for Caspian terns in Hawke's Bay. Large numbers of black backed gulls, bar-tailed godwit, black-fronted dotterel, spotless crake and Australasian bittern are also associated with this site. Important whitebait spawning sites are found here, with the estuary and river mouth providing passage for diadromous fish.
Waitangi Estuary	The lower reaches of this estuary are a designated Wildlife Refuge due to the presence of important coastal wetland habitat (mudflat, saltmarsh, reed and succulent herb swamp). Banded dotterel, black-fronted dotterel, pied stilt, white-fronted tern and black-billed gulls nest along the bar at the mouth of the estuary. The estuary supports black-fronted terns in winter and migratory waders. The estuary is classed as a nationally important fisheries habitat as it is one of the largest whitebait spawning sites in Hawke's Bay. In addition, a number of other diadromous native fish depend on the estuary for access to river catchments.
Ahuriri Estuary	The estuary and surrounding area are of major significance to tangata whenua and are subject to a claim before the Waitangi Tribunal; numerous sites of cultural, historic and archaeological significance are located on the shore. A Wildlife Refuge covers part of this site. The estuary has high natural values and is an important breeding and feeding area for marsh crake, Australaisan bittern, grey teal, New Zealand shoveller and pied stilt. The lower tidal flats are feeding areas for royal spoonbill and migratory waders (eastern bar-tailed godwit and Pacific golden plover). The estuary is classed as a nationally significant fisheries habitat and is the most important estuary in Hawke's bay in terms of fisheries production; it provides nursery, spawning and feeding habitat and acts as a migratory corridor. Eleven fish species breed in the estuary, nine of which have commercial value. This site is a nationally significant coastal landform.

4.3.1.7 Horizons Regional Council Protection Management Areas

Within their Coastal Plan; the One Plan, Horizons Regional Council have identified a number of areas as Protection Activity Management Areas. These areas are considered to be sensitive and have been identified for the purpose of protecting their ecological and other important characteristics (HRC, 2014).

Cape Turnagain is the only site within the jurisdiction of Horizons Regional Council that has been listed in the current One Plan as a Protection Management Area (HRC, 2014).

Cape Turnagain is a headland that lies halfway between Hawke's Bay and Cook Strait. This point marks the southernmost extent and subsequent turning point of James Cook's 1969 voyage. The headland is valued for its visual and scenic characteristics, in particular its prominence within the Horizons region. Cape Turnagain is ecologically significant and provides important habitat for little penguins and is a haul out area for New Zealand fur seals. This site is highly valued for its significance to Maori, as well as its historical heritage, archaeological sites and high potential for archaeological discoveries (HRC, 2014).

4.3.1.8 Greater Wellington Regional Council Areas of Significant Conservation Value Important Conservation Value

Greater Wellington Regional Council has listed a number of sites as 'Areas of Significant Conservation Value' and 'Areas of Important Conservation Value'. The aim of identifying these sites is to provide protection for, and recognition of, habitats and areas that are important for traditional, cultural, historic, biological and geological reasons (GWRC, 2000).

Areas of Significant Conservation Value and Areas of Important Conservation Value that have been identified within the Greater Wellington Regional Council Coastal Plan (2000) and that are of relevance to the Operational Area are provided in **Table 11** and **Table 12** respectively.

Table 11 Greater Wellington Regional Council Areas of Significant Conservation Value

Site	Value
Lake Onoke	Contains wildlife and conservation values. This site is a breeding ground for threatened bird and fish species. Vegetation at this site includes rare and vulnerable native species.
Castlepoint	This site contains high scientific, wildlife, geological, scenic, natural, and conservation values. Castlepoint is naturally vegetated with fragile coastal species including some rare species. It provides habitat for marine mammals and breeding grounds for birds. Castlepoint supports an internationally significant rock lobster larvae population. This site is also an important physical and geological landscape.

Table 12 Greater Wellington Regional Council Areas of Important Conservation Value

Site	Value
Whakataki – Mataikona Foreshore	This site contains geological features of regional significance including a tongue and groove shore platform at Whakataki. Significant habitats for wildlife are also found at this site.
Kaiwhata River Outlet	Kaiwhata River Outlet contains fossil forest of national significance.
Kahau Rocks	Kahau Rocks are an outstanding natural landscape feature and the offshore reef system is a site of regional significance for indigenous flora and fauna. A winter haulout for New Zealand fur seals is also present at this site.
Honeycomb Rock	Honeycomb Rock is an outstanding natural landscape feature and the offshore reef system is a site of regional significance for indigenous flora and fauna. A winter haulout for New Zealand fur seals is also present at this site.
Cape Palliser – Kupe's Sail	This site contains geological formations of regional significance. Cape Palliser contains a regionally significant seal rookery and red-billed gull breeding colony.
Turakirae head	Turakirae head is of national significance as a geological feature. Wildlife values at this site are also high as it supports a regionally significant haulout for New Zealand fur seals.
Te Aroaroa Kupe (Steeple Rock)	This site is valued for its importance to tangata whenua.
Tarakena Bay	Tarakena Bay is valued for its cultural significance; this bay is an important waka landing place.
Tauputeranga Island	Tauputeranga Island is classed as an outstanding natural and landscape feature with regionally significant flora and fauna. It is also of importance to tangata whenua.
Red Rocks – Sinclair Head	This site includes the margins of Red Rocks and Sinclair Heads Scientific Resreves. It is a winter haulout area for New Zealand fur seals and is of importance to tangata whenua for its cultural and spiritual values.

4.3.1.9 Marlborough District Council Areas of Ecological Value, Areas of Significant Conservation Value and Significant Marine Sites

The Marlborough Sounds Resource Management Plan (2003) lists a number of sites as 'Areas of Ecological Value', however these sites are not of relevance to the Operational Area.

The Wairau Awatere Resource Management Plan (2009) provides for the management of the coastal environment on the exposed coast to the south-east of the Marlborough Region. Within this Management Plan are a number of sites that have been classified as 'Areas of Significant Conservation Value'. These sites and their marine and coastal conservation values have been provided below in **Table 13**.

Table 13 Marlborough District Council Wairau/Awatere Areas of Significant Conservation Value

Site	Value
Whites Bay, Cloudy Bay	This site contains a large variety of exposed marine life, sandy coast, sand, and a regionally unique tussock and spinifex community.
Rarangi, Cloudy Bay	This site contains a large variety of exposed marine life, sandy coast, sand, and a regionally unique tussock and spinifex community.
Wairau Lagoons	The Wairau Lagoon is the largest biologically important estuary on the east coast. 90 bird species have been recorded here, 27% of which are endangered, vulnerable, or rare. 22 species of fish, including flatfish and whitebait have also been recorded in the lagoon which acts as a nursery area. White bluffs and a boulder bank are dominant features of the lagoon.
White Bluffs, Cloudy Bay	The Wairau Lagoon is the largest biologically important estuary on the east coast. 90 bird species have been recorded here, 27% of which are endangered, vulnerable, or rare. 22 species of fish, including flatfish and whitebait have also been recorded in the lagoon which acts as a nursery area. White bluffs and a boulder bank are dominant features of the lagoon.
Seaview, Clifford Bay	This site is a Scientific Reserve due to the presence of threatened flora.
Cloudy Bay Hector's Dolphin Area	Cloudy Bay contains a nationally large population of Hector's dolphins.
Clifford Bay Hector's Dolphin Area	Clifford Bay contains a nationally large population of Hector's dolphins.
Cape Campbell Kelp Beds and Shore Platforms	This site is valued for its marine habitat including large beds of *Macrocystis pyifera* (kelp).
Chancet Rocks	This site is valued for its high degree of natural character and contains silicified fossil sponges. Chancet Rocks are a haulout area for New Zealand fur seals.
Needles	This site is valued for its high degree of natural character and contains silicified fossil sponges. It is a haulout area for New Zealand fur seals.
Mirza Creek	This site is valued for its high degree of natural character and contains silicified fossil sponges. It is a haulout area for New Zealand fur seals.

Marlborough District Council, DOC and marine scientists have identified additional sites within the Marlborough Region as 'Sites of Ecological Significance' based on conservation, scientific and/or ecological values (Davidson *et al.,* 2011). These sites have been described below in **Table 14**; however, it is worth noting that only some of the sites present in Biogeographic Zones 7 – 9 are of relevance to the Operational Area. It is also important to note that there may be some overlap with the sites identified in the Davidson *et al.* (2011) report and the Wairau/Awatere Management Plan (2009).

Table 14 Marlborough Sites of Ecological Significance

Site	Value
Biogeographic Zone 7 (Cape Jackson – Rarangi)	
Cook Strait Whale Migratory Corridor	This site is part of a migratory corridor along New Zealand's coast for the northern migrations of humpback whales. This area is also used by other large whales including southern right whales (winter months), blue whales (possibly year round), and sperm whales (year round in deeper waters). Minke and killer whales, dusky, common, bottlenose, and Hector's dolphins have also been observed in the Strait.
Biogeographic Zone 8 (Cloudy and Clifford Bays)	
Cloudy and Clifford Bays	These bays support more individual dolphins than any other area in Marlborough, with dolphins present here year-round.
Wairau Lagoon	Wairau Lagoon is the largest and most biologically important estuary on the South Island's east coast. 90 species of birds have been recorded here; 77% are endemic or native, 27% are endangered, vulnerable or rare. The lagoon is an important nursery area for at least two species of flatfish.
Lake Grassmere	The tidal lagoon of Lake Grassmere is visited by a number of migrating wading birds. Estuaries are not common along Marlborough's east coast.
Biogeographic Zone 9 (South of Cape Campbell to Willawa Point)	
Cape Campbell to Ward (inshore subtidal)	This coast is characterised by rocky reefs interspersed by sand or gravel beaches and is one of three sites in New Zealand where the endemic mottled brotulid (a species of fish) has been found.
Cape Campbell to Ward (offshore subtidal)	This stretch of coast is one of three sites in New Zealand where the endemic mottled brotulid (a species of fish) has been found.

4.3.1.10 Environment Canterbury Areas of Significant Natural Value

Environment Canterbury has identified areas within the CMA of the Canterbury Region as 'Areas of Significant Natural Value' based on their high natural, physical, heritage, or cultural values. The Areas of Significant Natural Value within the Canterbury Region that are of relevance to the Operational Area (i.e. as far south as Banks Peninsula) are presented in **Table 15** based on descriptions in the Regional Coastal Environment Plan for the Canterbury Region (ECan, 2005).

Table 15 Environment Canterbury Areas of Significant Natural Value

Site	Value
Clarence River Mouth	This site contains the following values: protected areas; marine mammals and birds; ecosystems, flora and fauna habitats; and historic places.
Waipapa to Irongate	This site contains the following values: Maori cultural values; protected areas; marine mammals and birds; ecosystems, flora and fauna habitats; scenic sites; historic places; and coastal landforms and associated processes.
Kaikoura Peninsula	This site contains the following values: Maori cultural values; protected areas; marine mammals and birds; ecosystems, flora and fauna habitats; scenic sites; historic places; and coastal landforms and associated processes.
South Bay to Peketa	This site contains the following values: protected areas; marine mammals and birds; ecosystems, flora and fauna habitats; historic places; and coastal landforms and associated processes.

In addition to the sites listed in **Table 15** as 'Areas of Significant Natural Value', there are additional sites classified by Environment Canterbury as 'Areas of High Natural, Physical, Heritage or Cultural Values'. These sites have been assessed based on similar criteria to the Areas of Significant Natural Value. Due to the high number of Areas of High Natural, Physical, Heritage or Cultural Values and their similarity to the Areas of Significant Natural Value, these sites have not be listed in this document; however, they are available from Schedule 2 of the Regional Coastal Environment Plan for the Canterbury Region (ECan, 2005).

4.3.2 Sensitive Sites Defined in the EEZ Act

Schedule 6 of the EEZ Act – Permitted Activities Regulations, 2013 contains a list of 12 habitats that are classed as sensitive environments based on a number of indicators (**Table 16**). These sensitive sites and their potential to be present within the Operational Area are further discussed below.

Table 16 Schedule 6 Sensitive Sites Defined in the EEZ Act - Permitted Activities Regulations, 2013

Sensitive Environment	Indicator of Existence of Sensitive Environment
Stony coral thickets or reefs	A stony coral thicket or reef exists if: • A colony of a structure-forming species (i.e. *Madrepora oculata, Solenosmilia variabilis, Goniocorella dumose, Enallopsammia rostrate, Oculina virgosa*) covers 15% or more of the seabed in a visual imaging survey of 100 m² or more; or • A specimen of a thicket-forming species is found in two successive point samples; or • A specimen of a structure-forming species if found in a sample collected using towed gear
Xenophyophore (sessile protozoans) beds	A xenophyophore bed exists if average densities of all species of xenophyophore found (including fragments) equal or exceed 1 specimen per m² sampled.
Bryozoan thickets	A bryozoan thicket exists if: • Colonies of large frame-building bryozoan species cover at least 50% of an area between 10 m² and 100 m²; or • Colonies of large frame-building bryozoan species cover at least 40% of an area that exceeds 10 km²; or • A specimen of a large frame-building bryozoan species is found in a sample collected using towed hear; or • One or more large frame-building bryozoan species is found in successive point samples.

Sensitive Environment	Indicator of Existence of Sensitive Environment
Calcareous tube worm thickets	A sensitive tube worm thicket exists if: • One or more tube worm mound per 250 m² is visible in a seabed imaging survey; or • Two or more specimens of a mound-forming species of tube worm are found in a point sample; or • Mound-forming species of tube worm comprise 10% or more by weight or volume of a towed sample.
Chaetopteridae worm fields	A sensitive chaetopteridae worm field exists if worm tubes or epifaunal species; • Cover 25% or more of the seabed in a visual imaging survey of 500 m² or more; or • Make up 25% or more of the volume of a sample collected using towed gear; or • Are found in two successive point samples.
Sea pen field	A sea pen field exists if: • A specimen of sea pen is found in successive point samples; or • Two or more specimens of sea pen per m² are found in a visual imaging survey or a survey collected using towed gear.
Rhodolith (maerl) beds	A rhodolith bed: • Exists if living coralline thalli are found to cover more than 10% of an area in a visual imaging survey; • Is to be taken to exist if a single specimen of a rhodolith species is found in any sample.
Sponge gardens	A sponge garden exists if metazoans of classes Demospongiae, Hexactinellidae, Calcerea, or Homoscleromorpha; • Comprise 25% or more by volume of successive point samples; or • Comprise 20% or more by volume of any sample collected using towed gear; or • Cover 25% or more of the seabed over an area of 100 m² or more in a visual imaging survey.
Beds of large bivalve molluscs	A bed of large bivalve molluscs exists if living and dead specimens; • Cover 30% or more of the seabed in a visual imaging survey; or • Comprise 30% or more by weight or volume of the catch in a sample collected using towed gear; or • Comprise 30% or more by weight or volume in successive point samples.
Macro-algae beds	A macro-algae bed exists if a specimen of a red, green, or brown macro-alga is found in a visual imaging survey or any sample.
Brachiopods	A brachiopod bed exists if one or more live brachiopod; • Is found per m² sampled using towed gear; or • Is found in successive point samples.
Deep-sea hydrothermal vents	A sensitive hydrothermal vent exists if a live specimen of a known vent species is found in a visual imaging survey or any sample.
Methane or cold seeps	A methane or cold seep exists if a single occurrence of one of the following taxa is found in a visual imaging survey or any sample: • Large siboglinid tubeworms *Lamellibrachia* sp; • Vesicomyid clams *Calyptogena* sp;

Sensitive Environment	Indicator of Existence of Sensitive Environment
	• Mussels in the family Bathymodiolinae; • Solemyid clams (*Acharax clarificata*); • The sponges *Stelletta* sp and *Pseudosuberites* sp; • Ampharetid, dorvilleid, and pogonophoran (*Siboglinum* sp) polychaete worms.

New Zealand stony coral thickets or reefs are formed by coldwater corals, usually in water depths between 200 and 2,000 m and at temperatures between 4 - 12 °C (MacDiarmid *et al.*, 2013). Knowledge on the location of such reefs in the southern hemisphere is lacking, however, small reefs up to 600 m long and 20 m wide have been observed on seamounts within New Zealand, while smaller patches have been observed on isolated rocks such as on phosphorite nodules in the Chatham Rise. There is potential for stony corals to occur within the Operational Area, and for the 'thicket' criteria to be met in areas with appropriate hard substrate available.

Xenophyophores are large single celled protozoans that form tests made up of mineral grains, sponge fragments and organic debris. Xenophyophores are particularly abundant below areas of high surface productivity and have been located on New Zealand's eastern, northern and western continental slopes and the Chatham Rise (MacDiarmid *et al.*, 2013). Xenophyophore beds could be present within the Operational Area.

Habitat-forming bryozoans are known to occur from latitudes 59 °N to 77 °S. They mainly occur over temperate continental shelfs in water depths less than 200 m on stable substrate in areas of high water flow. Bryozoans are particularly abundant and diverse in New Zealand waters (MacDiarmid *et al.*, 2013). It is possible that bryozoan thickets may be present within the Operational Area.

A number of tube worm species found within New Zealand secrete calcium carbonate tubes. In high enough densitites these worms form calcareous tube worm thickets. The most well described mound forming species in New Zealand is *Galeolaria hystrix*, which serves as a general example for calcareous tube worm thickets. Thickets are found on both hard and soft substrates; however, some form of hard substrate is usually needed on which the mound initially establishes. Calcareous tube thickets are usually found in shallow water depths (6 – 30 m). Although it is possible for thickets to occur in deeper water if conditions are suitable, calcareous tube worm thickets are thought to be rare in the EEZ (MacDiarmid *et al.*, 2013); hence calcareous tube worm thickets are not expected in the Operational Area.

Chaetopteridae worm fields are formed by a number of tubeworm species when they reach sufficient sizes and/or densities to provide biogenic habitat. The species *Phyochaetopterus socialis* (also known as tarakihi weed) is a common species off the east coast of the South Island and may also be present around the North Island. This species typically occurs in coastal and shelf waters at depths of 70 – 110 m (MacDiarmid *et al.*, 2013). Due to their preferred depth and known distribution, it is possible that chaetopteridae worm fields are present within the Operational Area.

Sea pens are colonial cnidarians (closely related to corals) that anchor themselves to the seabed and extend an erect stalk into the water column. High densities of sea pens are referred to as a sea pen field. Sea pens are found on soft substrates in deeper waters over the continental shelf, slope and abyssal plains. Little is known of the distribution of sea pen fields in New Zealand's EEZ; however, individual sea pens are often observed during scientific research (MacDiarmid *et al.*, 2013). It is likely that sea pen fields will be present within the Operational Area.

Rhodoliths are free-living calcified red algae that form complex ‘bed’ habitats. Rhodolith beds are largely undescribed in New Zealand, although known locations include North Cape, Bay of Islands, Kaipiti Island, Marlborough Sounds, and Foveaux Strait. They are also thought to occur in water depths down to 200 m in locations characterised by strong currents, such as the margins of reefs or elevated banks (MacDiarmid *et al.*, 2013). It is therefore possible for rhodolith beds to be present in the Operational Area, particularly in shallower waters.

Sponges are dominant in many marine environments. New Zealand has a high diversity of sponges, with over 500 species recognised. Known sponge gardens within or close to the Operational Area include the Chatham Rise seamounts (200 – 1,200 m water depth), and the ‘Hay Paddock’ in North Canterbury (80 – 120 m water depth) (MacDiarmid *et al.*, 2013). It is likely that sponge gardens are present within the Operational Area.

Aggregations of infaunal bivalve molluscs such a cockles are referred to as ‘beds’, while aggregations of emergent species such as mussels are referred to as ‘reefs’. Bivalve beds/reefs are present throughout the EEZ, mainly on the continental shelf in water depths less than 250 m. Common species encountered in the EEZ include, but are not limited to, horse mussels, scallops, and dredge mussels (MacDiarmid *et al.*, 2013). Based on the depth distribution of bivalve molluscs, it is possible for large beds/reefs to be present within Operational Area.

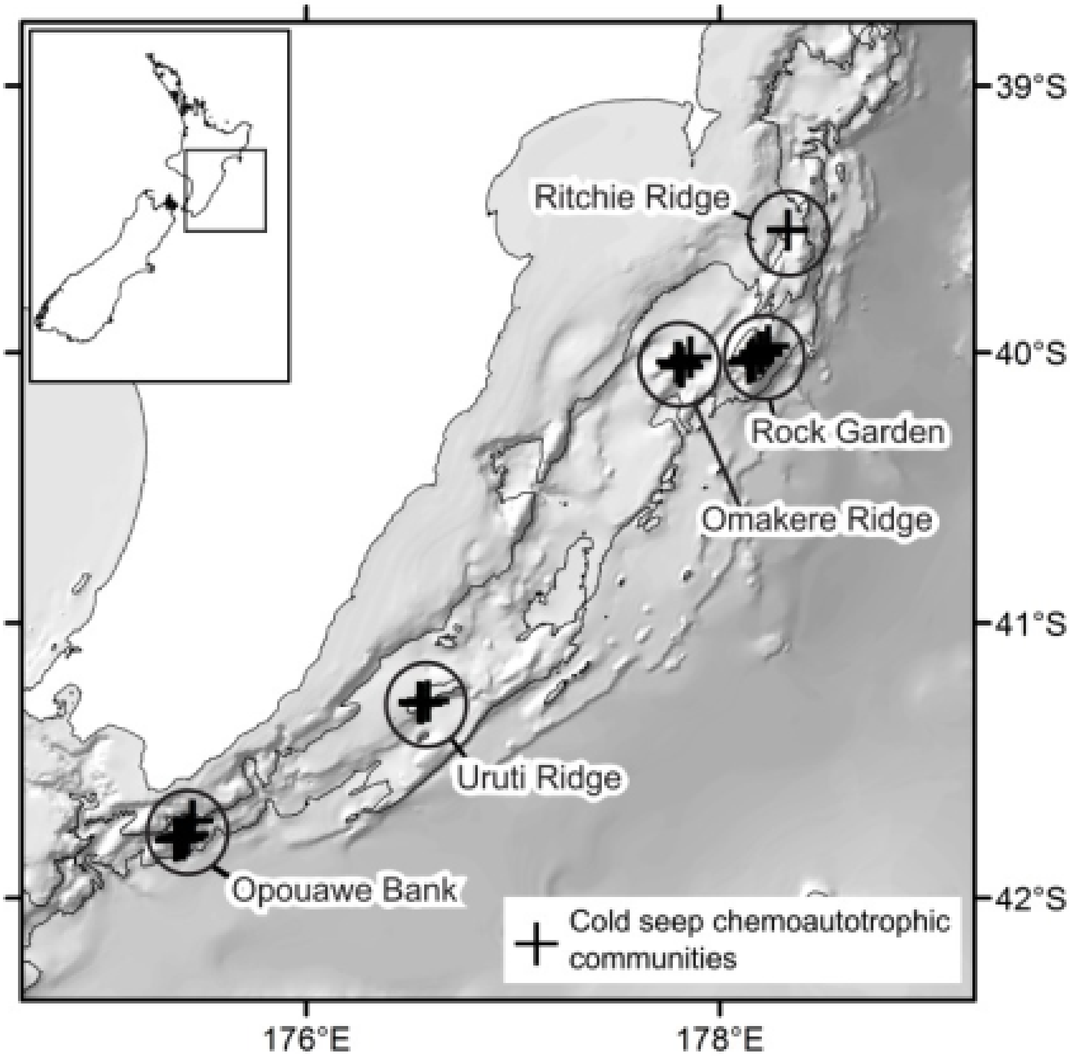
Macroalgae beds are usually found on hard rocky substrates within the inshore zone; however, some species have been recorded in the EEZ on offshore rocky outcrops (e.g. the ‘true kelps’ *Lessonia variegata* and *Ecklonia radiata*) to depths greater than 25 m (down to 70 m in clear oceanic waters), and non-emergent reefs below 30 m water depth (e.g. the brown algae *Carpomitra costata* and *Halopteris* sp.). Species of bull kelp are restricted to shallow coastal waters. A number of red and green algae have been recorded at offshore reefs in 30 to 200 m water depth including 31 red algae and seven green algae species (MacDiarmid *et al.*, 2013). It is possible for macroalgae beds to be present within Operational Area; however, this distribution is reliant on the presence of offshore rocky reefs in areas shallower than 200 m. By far the majority of macroalgae beds will be present inshore of the Operational Area.

Brachiopods are small, bilaterally symmetrical filter feeders commonly mistaken for bivalve molluscs. Adult brachiopods generally require hard substrate such as rock, gravel or shell debris to anchor to. Beds of brachiopods are found throughout New Zealand in areas with significant water movement that are free of fine sediments. The Chatham Rise is known to have a high diversity and abundance of brachiopods and represents a northern limit for some of the southern and subantarctic species (MacDiarmid *et al.*, 2013). It is likely that brachiopod beds will be present within the Operational Area.

Deep-sea hydrothermal vents are underwater hot springs and occur in areas on the seabed where cold water filters through the seabed and is heated by geothermal energy. As the water heats it becomes buoyant and rises towards the seabed where it dissolves metals and sulphides from the rocks. The heated water is ‘vented’ from a point source, e.g. a chimney made from precipitated minerals, a crack or fissure in the seabed, or by diffusion through sand and mud (MacDiarmid *et al.*, 2013). The distribution of hydrothermal vents in New Zealand is associated with the subduction zone of the pacific plate under the Australian plate in northern New Zealand. As a result, all known deep-sea hydrothermal vents in New Zealand are restricted to the north of the Bay of Plenty and on seamounts along the Kermadec Volcanic Arc (de Ronde *et al.*, 2001); therefore, it is unlikely that hydrothermal vents will be present within the Operational Area.

Methane or cold seeps occur where methane-rich fluid is released from underlying sediments into the water column. These sites are usually associated with areas where gas hydrates occur within the sediments (MacDiarmid *et al.*, 2013). Gas hydrates only occur in the 'gas hydrate stability zone'; typically within 500 m beneath the seabed and in water at least 500 m deep (MacDiarmid *et al.*, 2013). Cold seeps occur when the gas hydrate stability zone ruptures (as the result of geological faulting, uplift or seabed slumping) causing a persistent release of fluids and free gas (MacDiarmid *et al.*, 2013). The resulting biological community is dominated by chemoautotrophic benthic organisms that depend on symbioses with chemosynthetic bacteria that generate energy from methane (MacDiarmid *et al.*, 2013). Cold water seep organisms include large tube worms (from the Siboglinidae family), vesicomyid clams, bathymodiolin mussels (Baco *et al.*, 2010), siboglinid poronophorans, bivalves (thyasirids, solemyids and lucinids), gastropods (trochids and buccinids), sponges (cladorhizds and hymedesmids), bresiliid shrimp, amphipods, galathaeoid crustaceans, and polychaetes (polynoids, dorvelleids, hesionids, and ampharetids) (Levin, 2005). Research voyages along the east coast of the North Island have confirmed the presence of active and locally intense methane seeps and a number of relict seep sites along the Hikurangi Margin. Five principle sites have been identified and studied; Ritchie Ridge, Rock Garden, Omakere Ridge, Uruti Ridge, and Opouawe Bank (**Figure 16**), with 32 active seeps confirmed (Bowden *et al.,* 2013). These sites are located within the Operational Area.

Figure 16 Cold Seep Sites on the Hikurangi Margin



Source: Bowden et al., 2013

4.3.3 Protected Natural Areas

Protected Natural Areas are put in place for the conservation of biodiversity. They receive varying degrees of protection as a result of their recognised natural values. Protected Natural Areas are managed under six main pieces of legislation; the Conservation Act 1987, National Parks Act 1980, Reserves Act 1977, Wildlife Act 1953, Marine Reserves Act 1971, and the Marine Mammals Protection Act 1979.

Of relevance to the Operational Area are the following (**Figure 17)**:

- Marine Mammal Sanctuaries: the Clifford and Cloudy Bay Marine Mammal Sanctuary;
- Marine Reserves: Te Angiangi, Taputeranga, Hikurangi, Pohatu/Flea Bay, and Akaroa Marine Reserves;
- Other: the Kaikoura Whale Sanctuary, Ōhau Point New Zealand Fur Seal Sanctuary, Benthic Protection Areas and Seamount Closures.

Marine Mammal Sanctuaries are administrated by DOC and are established in order to protect marine mammals from harmful human impacts. They are usually established in areas that are important to particular mammals such as over breeding grounds or migratory routes (DOC, 2016e) and restrict activities such as seismic surveys and fishing.

The Clifford and Cloudy Bay Marine Mammal Sanctuary extends from Cape Campbell to a point 12 Nm offshore in a direct line to Tory Channel, covering an area of 142,716 ha and 338 km of coastline (DOC, 2016f). This sanctuary was established as Clifford and Cloudy Bays are strongholds for Hector's dolphins along the South Island's east coast. The sanctuary lies over 150 km to the west of the Operational Area.

There are three Marine Reserves located inshore of the Operational Area; Te Angiangi, Taputeranga, and Hikurangi Marine Reserves. The Marine Reserve status provides full protected of all things living and non-living within the reserve.

Located in central Hawke's Bay approximately 30 km east of Waipukurau and Waipawa (DOC, 2016g), the Te Angiangi Marine Reserve is the most northern Marine Reserve adjacent to the Operational Area. Te Angiangi was established in 1997 and covers an area of approximately 446 ha. The Marine Reserve protects a range of habitat types, including a boulder bank area, rocky platforms and a sheltered bay. A number of bird species can be observed at this reserve, and common and bottlenose dolphins are also regular visitors. Te Angiangi Marine Reserve is easily accessible and is well used by locals (DOC, 2016g).

Taputeranga Marine Reserve lies on the south coast of the North Island, 6 km from Wellington's city centre. It was established in 2008 and protects a total area of 854 ha, including approximately 5 km of shoreline from the west of Owhiro Bay to west of Te Raekaihau Point. The Marine Reserve is rich in marine life; over 180 species of fish have been recorded along the south coast, almost half of New Zealand's seaweeds can be found within the reserve, and a large number of seabirds are also present. Marine mammals are often sighted, with common dolphins a regular sight and whales occasional visitors. Due to its close proximity to the capital, Taputeranga Marine Reserve is a popular location for snorkelling and diving (DOC, 2016h).

The Hikurangi Marine Reserve forms part of the Kaikoura Marine Strategy and is implemented through the Kaikoura (Te Tai ō Marokura) Marine Management Act 2014. The Marine Reserve is located near the Kaikoura Township where the Kaikoura Canyon approaches close to the land. Its boundaries extend offshore for 23.4 km and along 1.95 km of coastline. The Hikurangi Marine Reserve protects an abundance of marine life, due to the inclusion of part of the Kaikoura Canyon. Within the reserve are rich seaweed, invertebrate and fish communities, and high abundances of seabirds such as albatross, petrels, shearwaters and prions. Marine mammals are present year-round, including resident populations of sperm whales, dusky dolphins and New Zealand fur seals. Orca are regular visitors to the area, and humpback whales are present during their northern winter migrations. Small pods of Hector's dolphins can be seen close to shore (DOC, 2016i).

Te Rohe o Te Whanau Puha (the Kaikoura Whale Sanctuary) was established in 2014 through the Kaikoura (Te Tai ō Marokura) Marine Management Act 2014 in order to protect whales and their habitats by reducing or eliminating potential impacts from seismic surveys. The sanctuary stretches along 91 km of shoreline and extends out beyond the 12 Nm CMA boundary to a maximum of 56 km from shore. The total area covers 4,686 km². The sanctuary is divided into an inner and outer zone, with tighter restrictions on seismic survey activities within the inner zone compared to the outer zone (DOC, 2016j).

The Ōhau Point New Zealand Fur Seal Sanctuary was also established in 2014 under the Kaikoura (Te Tai ō Marokura) Marine Management Act 2014. The sanctuary is located at the Ōhau Point seal colony; the most significant breeding colony for New Zealand fur seals on the east coast of the South Island. It includes a portion of the shoreline and intertidal seal habitat. The sanctuary was established in order to limit human disturbance to seals, while also allowing for public viewing of the colony. Public walking access within the sanctuary is prohibited, although the public are still able to observe seals from the existing viewing area above the colony, from the beach on each end of the colony, and in the crèche waterfall pond (DOC, 2016j).

Benthic Protection Areas are areas within New Zealand's EEZ that have been closed to dredging and with trawling restrictions in place. These closures were brought about in 2007 by the fishing industry. A total of 17 areas have been established as Benthic Protection Areas, with the intention to prohibit bottom trawling while allowing for mid-water trawling. In 2001 17 Seamount Closures were also established. Seamount Closures differ to Benthic Protection Areas in that both bottom trawling and mid-water trawling are prohibited. In combination Benthic Protection Areas and Seamount Closures cover 32% of New Zealand's EEZ, including 28% of underwater topographic features (including seamounts), 52% of seamount over 1,000 m in height, and 88% of known hydrothermal vents (MFish, 2010). The Mid Chatham Rise and Hikurangi Deep Benthic Protection Areas are closest Benthic Protection Areas to the Operational Area, while the Morgue, Pyre/Gothic and Pinnie Seamount Closures are the closest Seamount Closures (**Figure 18**).

Figure 17 Protected Natural Areas near the Operational Area

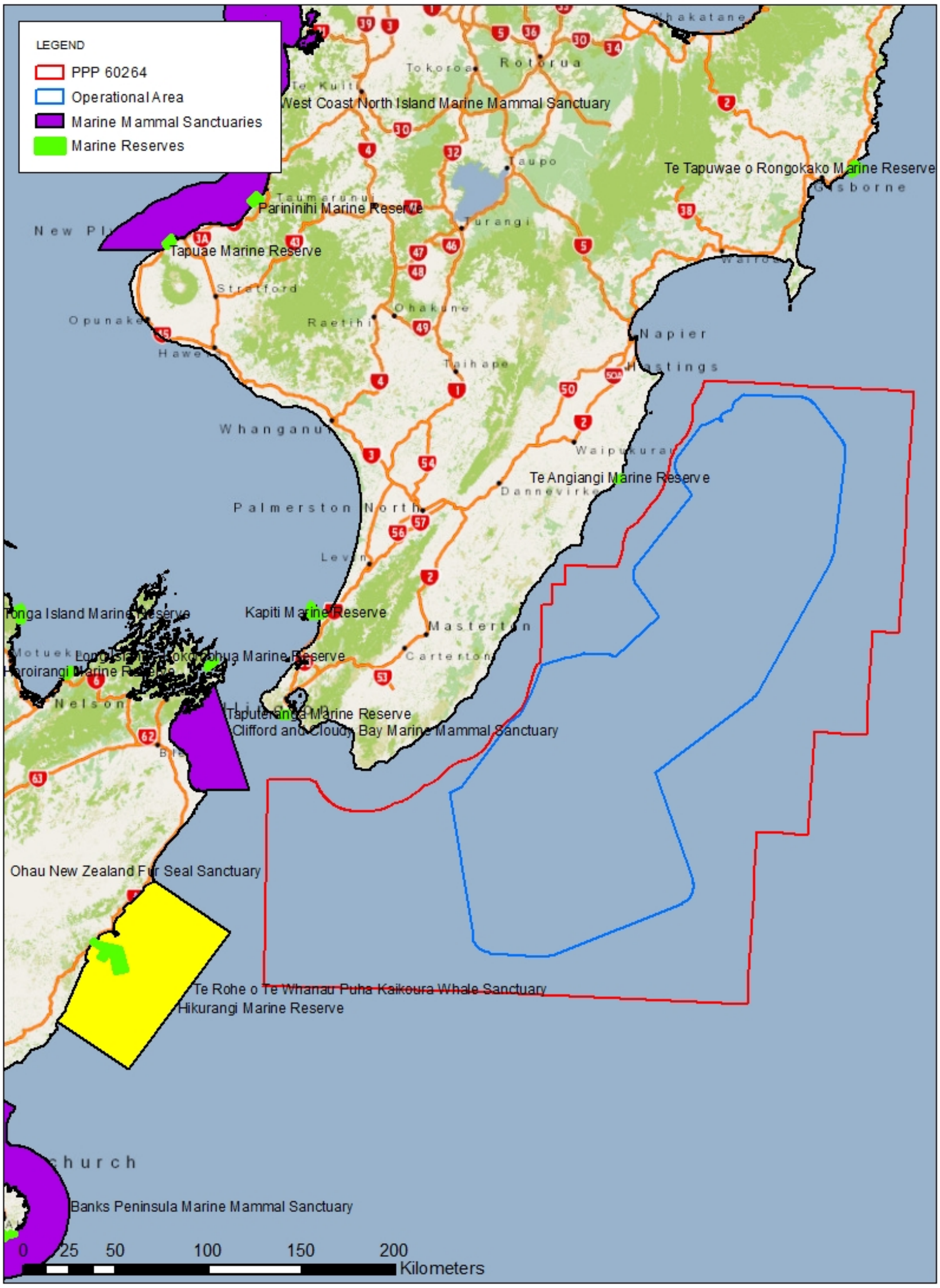
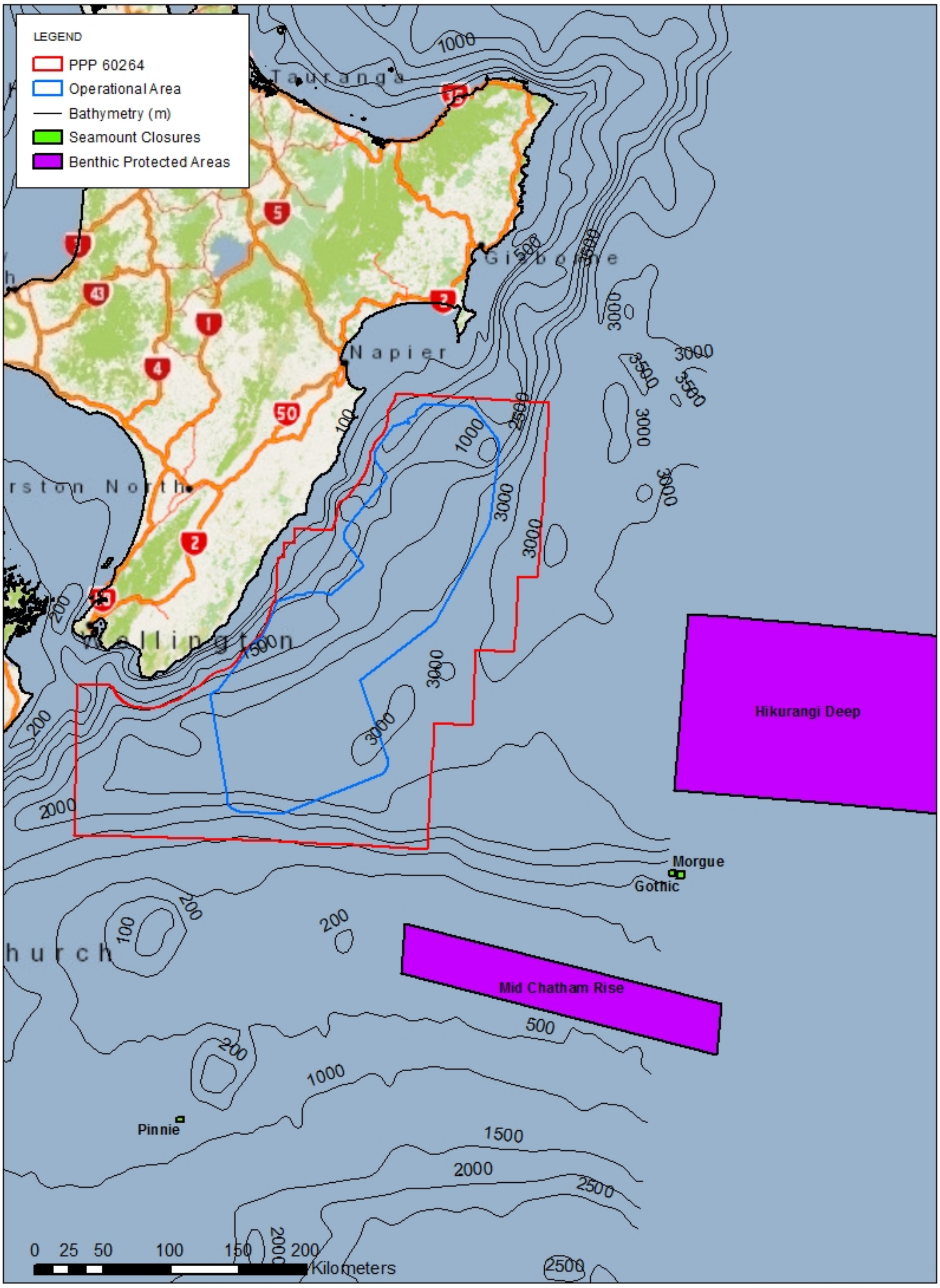


Figure 18 New Zealand Benthic Protection Areas



4.3.4 New Zealand Marine Environmental Classification

The New Zealand Marine Environment Classification covers New Zealand's Territorial Sea and EEZ and provides a spatial framework for structured and systematic management. Geographic domains are divided into units that have similar environmental and biological characters (Snelder *et al.,* 2005). Units are characterised by physical and biological factors (i.e. depth, solar radiation, sea surface temperatures, waves, tidal current, sediment type, seabed slope, and curvature).

Under the NZ Marine Environmental Classification 20-class level, the Operational Area covers groups 22, 47, 55, 58, 60 and 63 (**Figure 19**). These groups are described in further detail below, following the definitions by NIWA (Snelder *et al*., 2005).

Class 22: is extensive in moderately deep waters (mean = 1,879 m) and is typified by cooler winter SST. Chlorophyll-*α* only reaches low average concentrations, with characteristic fish species being orange roughy, Baxter's lantern dogfish, Johnson's cod and hoki.

Class 47: occurs extensively in deep waters (mean = 2,998 m). Average chlorophyll-*α* concentrations are moderately low, with characteristic fish species including smooth oreo, Baxter's lantern dogfish, the rattail, Johnson's cod and orange roughy.

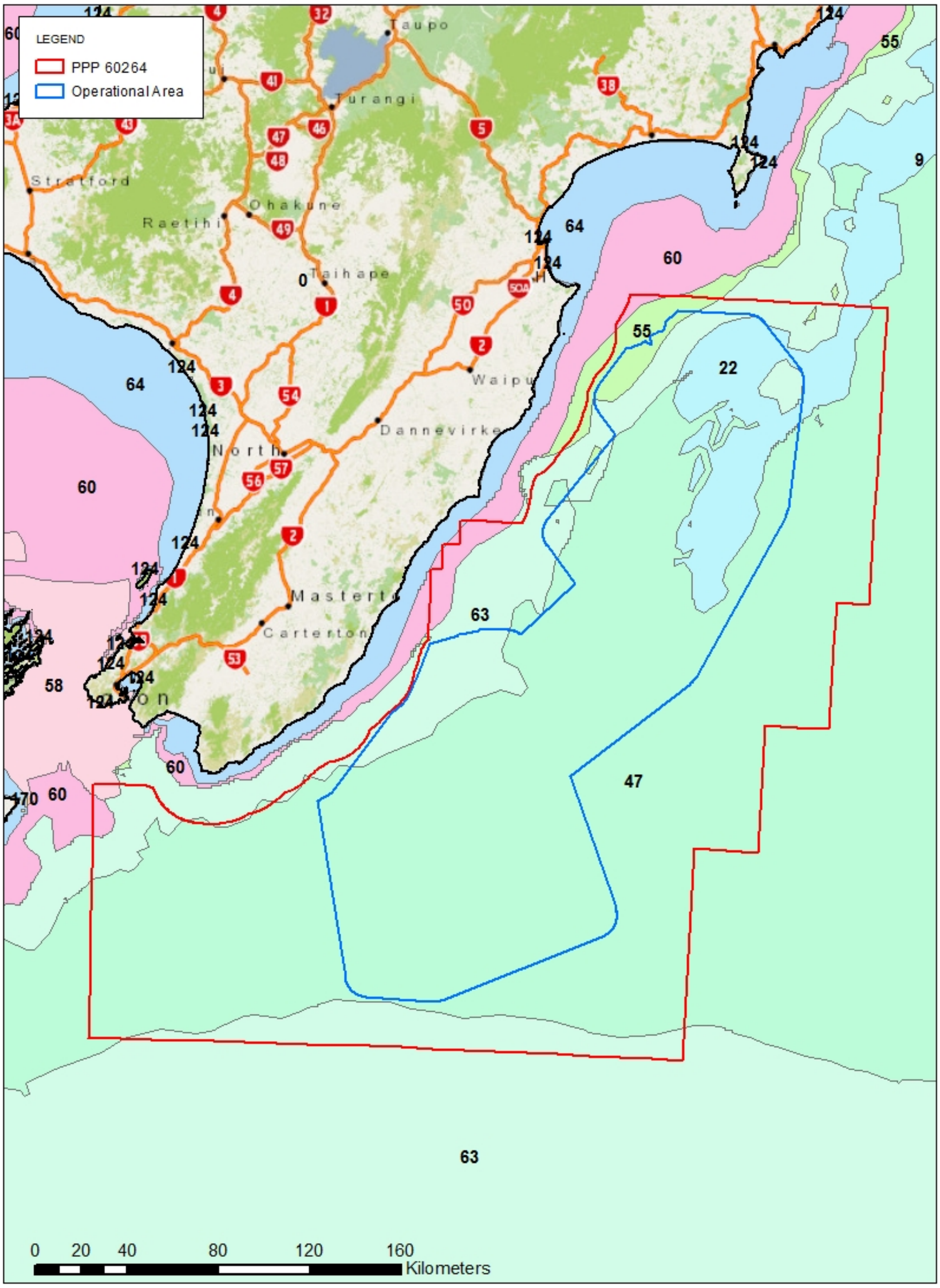
Class 55: is of restricted extent, occurring at moderately shallow depths (mean = 224 m) around northern NZ and has high annual solar radiation and moderately high winter SST. Average chlorophyll-*α* concentrations are moderate. Characteristic fish species include sea perch, red gurnard, snapper and ling, while arrow squid are also common. The most commonly represented benthic invertebrate families are Dentallidae, Nuculanidae, Pectinidae, Carditidae, Laganidae and Cardiidae.

Class 58: is restricted in extent and occurs in moderately shallow waters (mean = 117 m) around northern New Zealand and Cook Strait. Strong tidal currents are a dominant feature of this class. Common fish species include red gurnard, snapper, leather jacket, spiny dogfish, barracouta, hoki, and eagle ray. Trawlers also frequently catch arrow squid. The most commonly represented benthic invertebrate families are Veneridae, Carditidae, and Pectinidae.

Class 60 is an extensive central coastal environment that occupies moderately shallow waters (mean = 112m) on the continental shelf, from the Three Kings Islands south to about Banks Peninsula. It experiences moderate annual solar radiation and wintertime sea surface temperature, and has moderately average chlorophyll α concentrations. Commonly occurring fish species include barracouta, red gurnard, john dory, spiny dogfish, snapper and sea perch. Arrow squid are also frequently caught in trawls. The most commonly represent benthic invertebrate families are Dentaliidae, Cardiidae, Carditidae, Nuculanidae, Amphiruridae, Pectinidae, and Veneridae.

Class 63: is extensive on the continental shelf including much of the Challenger Plateau and the Chatham Rise. Waters are of moderate depth (mean = 754 m) and have moderate annual radiation and wintertime SST. Average chlorophyll a concentrations are also 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, Veneridae, Cardiidae, Serpulidae and Limidae.

Figure 19 New Zealand Marine Environmental Classifications around the Operational Area



4.4 Cultural Environment

Tangaroa (the ocean) is treasured by all Māori communities. It is valued as a source of kaimoana (seafood) and commercial fisheries, for its estuaries and coastal waters, for its sacred and spiritual pathways, and for transport and communication.

Māori believe in the importance of protecting Papatuanuku (earth) including the footprints and stories left on the whenua (land) and wai (water) by ancestors. In accordance with this, the role of kaitiakitanga (guardianship) is passed down from generation to generation. Kaitiakitanga is central to the preservation of wahi tapu (sacred places or sites) and taonga (treasures).

This section provides a brief overview of iwi (tribes) along the stretch of coastline relevant to the Operational Area and describes their rohe (area of interest) and the marine attributes of particular cultural interest. The Operational Area adjoins the rohe of twelve iwi (tribes) as listed in **Table 17**.

Whilst the North Island is home to many iwi groups, in the South Island, one tribe (Ngai Tahu) occupies all but the most northern part of the Island (**Figure 20**).

Figure 20 Iwi Boundaries of New Zealand

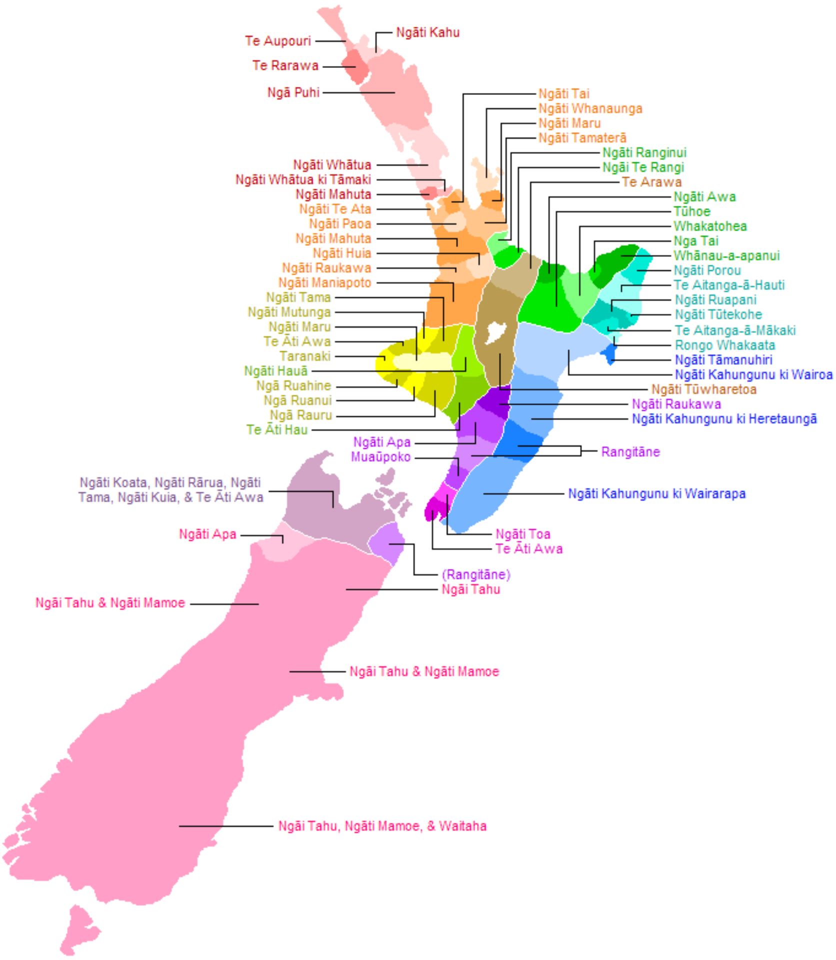


Table 17 Iwi with interests in the Operational Area

Iwi (tribal group)	Rohe (area of Interest)	Region/s	Taonga (treasured) species*	Further comments
Ngati Kahungunu (4 relevant taiwhenua /districts: Te Taiwhenua o Heretaunga, Te Taiwhenua o Tamatea, Te Taiwhenua o Tāmaki-nui-a-Rua and Kahungunu ki Wairarapa)	From Napier in the north to Tūrakirae Head, Palliser Bay in the south	Hawke's Bay Horizons Greater Wellington	Traditional kaimoana, e.g. rock lobster, paua, kina, mussels, pipi, paddle crabs and finfish – especially flatfish, gurnard, kahawai, red cod, snapper, tarakihi and trevally (Maxwell, 2012); also seaweed/karengo and other shellfish (Tumapuhia, 2013).	Water (both freshwater and marine) has high spiritual, social and cultural values to Maori forming a basis for identification, belonging and mana (pride) (HBRC, 2014). The coastal area provided a consistent source of food and acted as an important means of transport (Te Ara, 2016e).
Heretaunga Tamatea	From Napier in the north to Cape Turnagain in the south	Hawke's Bay	All species of fish, aquatic life and seaweed (Heretaunga Tamatea, 2015).	This iwi is actively involved with coastal management and Cape Kidnappers has immense cultural and historical significance (Heretaunga Tamatea, 2015).
Rangitāne (2 eastern taiwhenua: Rangitāne o Tāmaki nui ā Rua and Rangitāne o Wairarapa)	From Porangahau (near Cape Turnagain) in the north to Petone (near Wellington) in the south	Horizons Greater Wellington	Traditional kaimoana e.g. hapuku, kahawai, paua, kuku/kutae (mussels), pupu (cat's eye snail), limpet, rock lobster and edible seaweeds (Chrisp, 2002).	Coastal fishing was important to this iwi, particularly along the Wairarapa coastline, including Pahaoa, Waikekeno, Te Unuunu, and Mātaikona (Chrisp, 2002).
Taranaki Whānui ki Te Upoko o Te Ika	From Pipinui Point on the west coast to Mukamuka Stream in the southeast (Wellington)	Greater Wellington	All species of fish, aquatic life and seaweed. Eels and paua are named in particular (Port Nicholson Block, 2008)	This iwi believes that the natural environment is the basic foundation of individual well-being and places a strong emphasis on enhancing natural resources through ecosystem conservation and sustainability for the sake of future generations (Port Nicholson Block Settlement Trust, 2016).
Te Atiawa (Wellington)	From Pipinui Point on the west coast to Mukamuka Stream in the southeast (Wellington)	Greater Wellington	Seabirds (e.g. sooty shearwaters), fish (e.g. blue cod, blue moki, red moki, butterfish, tarakihi and groper), shellfish & invertebrates (e.g. rock lobster, paua, kina) and seaweed (e.g. karengo and bull kelp). (Raukura Consultants, 2015)	The Wellington coastal region was shared by a number of iwi who all considered the sea and associated kaimoana to be significant.
Ngāti Toa Rangatira (Te Tau Ihu/Top of the South)	Wellington and the entire top of the South Island from Hokitika to Kaikoura	Greater Wellington Marlborough Kaikoura	Seaweed, shellfish, fish, sea birds and marine mammals (e.g. stranded whales for their oil, flesh, bones and teeth and seals for their meat and skins (Te Tau Ihu*, 2014).*	Between 1820 and 1840 this iwi controlled their rohe (on both sides of the Cook Strait) from their fortress on Kapiti Island (Te Ara, 2016f).
Te Atiawa o Te Waka-a-Māui (Te Tau Ihu/Top of the South)	From Westport on the west coast to Grassmere (near Cape Campbell) on the east coast (i.e. around the entire top of the South Island)	Marlborough Kaikoura	Seaweed, shellfish, fish, sea birds and marine mammals (e.g. stranded whales for their oil, flesh, bones and teeth and seals for their meat and skins (Te Tau Ihu, 2014).	Te Atiawa was based in Queen Charlotte Sound from the early 1930s and was renowned for their maritime skills, keeping close links with the North Island through waka travel. This iwi continues to place high cultural values upon the foreshore, seabed and coastal and maritime waterways (Te Atiawa o Te Waka-a-Māui, 2012).
Rangitāne o Wairau (Te Tau Ihu/Top of the South)	From Mapua in Tasman Bay to Matariki Pā, at the mouth of the Clarence River in the east	Marlborough Kaikoura	Seaweed, shellfish, fish, sea birds and marine mammals (e.g. stranded whales for their oil, flesh, bones and teeth and seals for their meat and skins (Te Tau Ihu, 2014).	Rangitāne developed positions in the Wairau, Queen Charlotte Sound, Awatere and northern Kaikoura Coast in the 1820s (The Prow, 2016). The coastal marine area is culturally, spiritually, historically and traditionally significant (Te Tau Ihu, 2014).
Ngāti Rarua (Te Tau Ihu/Top of the South)	From Gillespie's Beach on the West Coast of the South Island to Nelson, and Cloudy Bay in Marlborough	Marlborough	Seaweed, shellfish, fish, sea birds and marine mammals (e.g. stranded whales for their oil, flesh, bones and teeth and seals for their meat and skins (Te Tau Ihu, 2014).	The coastal area provided this iwi with a bountiful supply of marine mammals, sea birds, shellfish, fish, and plant life (Te Tau Ihu, 2014).
Ngāti Kuia (Te Tau Ihu/Top of the South)	From Kahurangi Point in the west to Cloudy Bay in the east	Marlborough	Muttonbirds were harvested from the Marlborough Sounds and fish and shellfish were also harvested (Ngāti Kuia, 2010).	Ngāti Kuia used coastal resources and developed associated customs, including mahinga kai (harvesting areas) and tauranga ika (fishing grounds).
Ngāti Kōata (Te Tau Ihu/Top of the South)	From Kahurangi Point in the west to Cloudy Bay in the east	Marlborough	Seaweed, shellfish, fish, sea birds and marine mammals (e.g. stranded whales for their oil, flesh, bones and teeth and seals for their meat and skins (Te Tau Ihu, 2014).	As with other 'Top of the South' iwi, the coastal marine area is an integral part of this iwi's identity. The marine area is culturally, spiritually, historically and traditionally significant (Te Tau Ihu, 2014).
Ngāi Tahu	From the southeast end of Big Lagoon to Kahurangi Point (i.e. around the entire South Island except for the 'Top of the South')	Marlborough Canterbury	Seabirds and eggs, pinnipeds, stranded whales, shellfish, seaweeds and fish (see **Appendix D** for list of named species)	Mahinga kai (food gathering) underpins Ngāi Tahu culture; being central to cultural, spiritual, social and economic wellbeing (TKTTM, 2008). Ngāi Tahu have a strong cultural connection with whales (Jolly, 2014) and the coastal seas around Kaikoura provided an important trade route (TKTTM, 2008).

* Formal lists of taonga species are not typically available; however those species documented as providing traditional kaimoana have been included here

Māori people have a deep spiritual connection with whales and dolphins which are the focus of a number of myths and legends. The best known is perhaps the legend of Paikea the whale rider. This legend tells the story of an ancestor called Paikea who took part in a fishing trip during which his jealous brother sank the canoe. Paikea was rescued by a whale which carried him safely to the east coast of the North Island (Te Ara, 2016g). The Hawke's Bay has another legend about a local leader called Tūnui who rode a whale called Ruamano in the vicinity of Cape Kidnappers (Te Ara, 2016g). Whales are thought to provide safety at sea and reportedly guided the waka (canoes) on their great journey to New Zealand from the ancestral homelands in the Pacific.

A number of iwi recognise the significance of large scale bathymetric features and oceanic processes in the Operational Area. Of particular interest are the Hikurangi Channel and the Wairarapa Eddy.

The Hikurangi Channel lies in a water depth of approximately 2,500 m and runs parallel to the coast in a northeast to southwest direction. It is hypothesised that long-finned eels and some species of whales may utilise this channel system to migrate between New Zealand waters and those of the tropical pacific for the purpose of breeding activities.

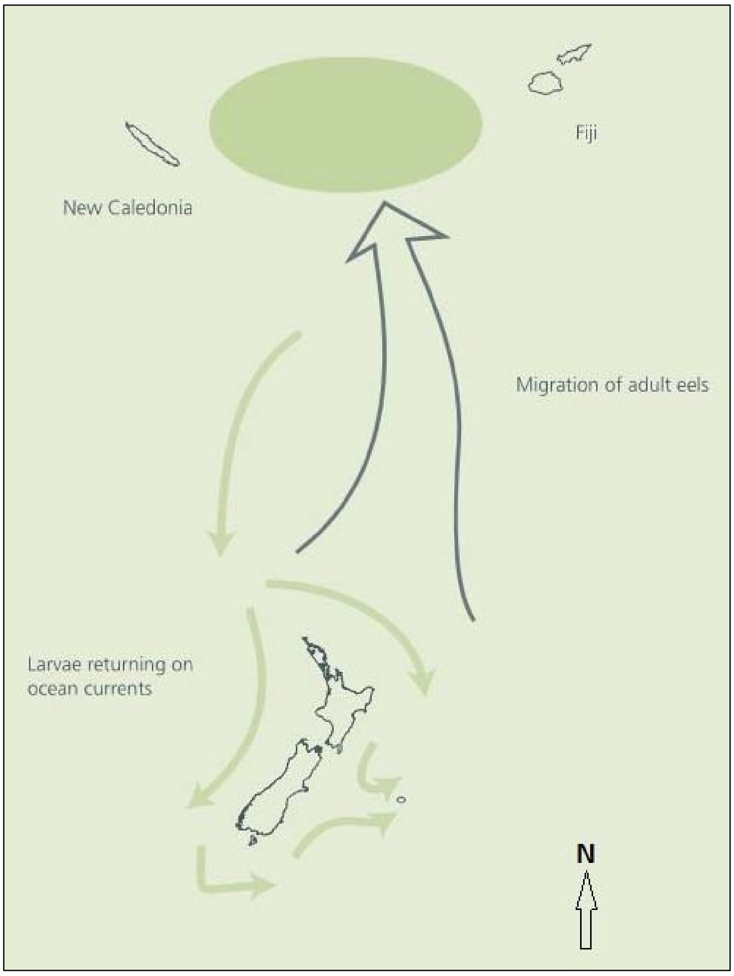
Long-finned and short-finned eels are present in freshwater systems throughout New Zealand. These eels live the majority of their lives in freshwater systems where they grow and mature into fertile adults. At this stage, the adult eels undergo physical changes before carrying out a single migration in autumn to Pacific Ocean spawning grounds. While the exact locations of eel spawning grounds are currently unknown, Tonga is thought to be an important area (Te Ara, 2016c). Eel migrations occur at night during dark phases of the moon, with movement also triggered by high levels of rainfall and river flow (Boubée *et al.,* 2001). Short-finned eels begin migrating in February and March, with the smallest males the first to start, followed by females in March and April. Long-finned eels migrate later, with males departing in April and females from April to June (NIWA, 2016).

Specific migration routes of eels are largely unknown. Long-finned eels are believed to migrate from New Zealand to spawning grounds by various routes. Within the Operational Area, the Hikurangi Channel is thought to be one pathway that the long-finned eel may use during migrations. A general overview of migration pathways is shown in **Figure 21**.

Once spawning has taken place, the adult eels die. Their eggs float to the ocean surface and hatch into transparent leaf-like larvae. Over the next 10 months, these larvae drift back to the New Zealand coast via oceanic currents. Once they reach the coast, larvae undergo further metamorphosis into small and slender transparent eels (known as 'glass eels') that settle in estuaries and river mouths. The glass eels move into freshwater waterways between July and November, with number peaking from August to October. The glass eels continue to develop, becoming greyish-brown as they migrate upstream and develop into adults. The average age at which adult short-finned eels migrate is 15 to 30, and 25 to 40 for long-finned eels (DOC, 2016l).

The Wairarapa Eddy occurs approximately 180 km off the Wairarapa coast and is a large, semi-permanent, rotational eddy (Chiswell, 2003). This feature is believed to be important for the retention of larvae for certain fisheries species as it provides a mechanism for larvae that is spawned in offshore waters to be returned to coastal New Zealand. Species that are thought to rely on the eddy for larval retention are rock lobster (Bradford *et al.*, 2005), alfonsino and cardinalfish (Smith & Paul, 2000), and hoki (Zeldis *et al.*, 1998).

Figure 21 Long-finned Eel Migration Paths



4.4.1 Customary Fishing and Iwi Fisheries Interests

Māori maintain a strong relationship with the sea; the collection of kaimoana is a fundamental part of their life. For coastal hapū, kaimoana is often vital to sustain the mauri (life force) of tangata whenua, and provides an important food source for whānau (family) and hospitality to manuhiri (guests). The prestige of providing kaimoana to visitors is noteworthy with regards to the significance of retaining access to kaimoana sources (Wakefield and Walker, 2005).

Under the Maori Fisheries Act (2004) recognised iwi across the country were allocated fisheries assets including fishing quota. In addition to the fishing quota held by individual iwi, each recognised iwi is allocated income shares in Aotearoa Fisheries Limited which is managed and overseen by Te Ohu Kai Moana (the Maori Fisheries Commission).

Iwi also have customary fishing rights (for special occasions and day-to-day use) under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 and the South Island Customary Fishing Regulations 1999. These regulations stem from the Treaty of Waitangi (Fisheries Claims) Settlement Act (1992) and are separate, and in addition to, the commercial fisheries assets described above. Under these regulations, Tangata Whenua traditional management practices to be put in place to govern fishing within an area that is deemed significant to Māori. Under these regulations Māori are able to gain permits to harvest kaimoana for customary purposes in a manner that is over and above that which would be allowed under standard recreational fishing rules (e.g. harvesting more than typically permitted or harvesting in closed areas) (Maxwell, 2012). The methods of establishing customary fishing rights are described below and are illustrated in **Figure 22**.

4.4.1.1 Rohe Moana

Under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 and the South Island Customary Fishing Regulations 1999, a 'rohe moana' can be established. Rohe moana are recognised traditional food gathering areas for which Kaitiaki (customary managers) can be appointed to manage kaimoana (seafood) collection in accordance with traditional Māori principles (tikanga). Rohe moana allow for management controls to be established, permits for customary take to be issued, penalties to be established for any management breach, and for restrictions to be established over certain fisheries areas to prevent stock depletion or overexploitation. Typically the legally recognised boundaries of rohe moana mirror the landward boundary of the Coastal Marine Area which is mean high water springs. A number of rohe moana occur within or adjacent to the Operational Area as listed below:

- Ngati Hinewaka me ona Karangaranga;
- Ngai Tumapuhiarangi, Ngati Hamua;
- Te Hika o Papauma;
- Ngati Kere;
- Kairakau Lands Trust;
- Ngai Hapu o Waimarama;
- Kahungunu ki te Matau a Maui; and
- Te Runanga o Kaikoura.

4.4.1.2 Mātaitai Reserves

Mātaitai Reserves recognise traditional fishing grounds and are established to provide for customary management practices and food gathering. Commercial fishing is prohibited within a Mātaitai Reserve; however, recreational fishing is allowed. The Mātaitai Reserves adjacent to the Operational Area are listed below:

- Te Waha o te Marangai Mātaitai lies just north of Kaikoura within the rohe of Ngāi Tahu and Ngāti Toa Rangatira (commenced on 11/07/2014 and measures 2 km^2);
- Maungamaunu Mātaitai lies just north of Kaikoura within the rohe of Ngāi Tahu and Ngāti Toa Rangatira (Commenced on 08/08/2014 and measures 2 km^2); and
- Oaro Mātaitai lies to the south of Kaikoura (Commenced on 08/08/2014 and measures <1 km^2).

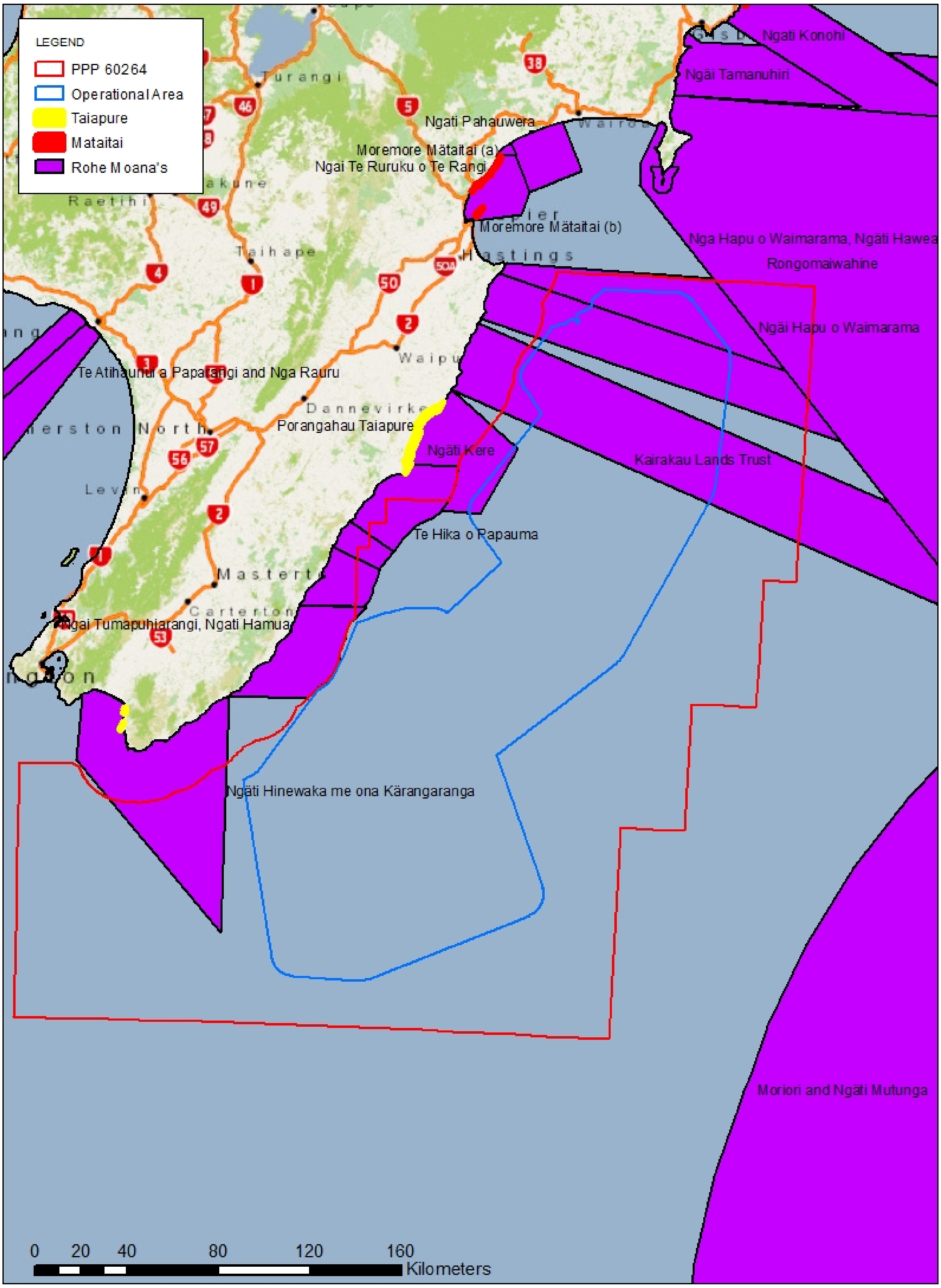
4.4.1.3 Taiapure

A Taiapure can be established in an area that has customarily been of significance to an iwi or hapū (sub-tribe) as either a food source or for cultural or spiritual reasons. A Taiapure allows Tangata Whenua to be involved in the management of both commercial and non-commercial fishing in their area but does not stop all fishing. The Taiapure adjacent to the Operational Area are listed below:

- Porangahau Tiapure lies off the coast of Porangahau in southern Hawke's Bay within the rohe of Heretaunga Tamatea and Rangitāne o Tāmaki nui ā Rua (commenced on 02/01/1997 and measures 61 km^2);
- Palliser Bay Tiapure lies off the coast of Palliser Bay to the east of Wellington within the rohe of Rangitāne o Wairarapa (commenced on 14/07/1995 and measures 3 km^2);
- Te Taumanu o Te Waka a Maui Taiapure (Kaikoura Peninsula Taiapure) lies off the coast of Kaikoura within the rohe of Ngāi Tahu and Ngāti Toa Rangatira (commenced on 08/08/2014 and measures 7 km^2); and
- Oaro Haumuri Taiapure (commenced on 08/08/2014 and measures 6 km^2).

It is important to note that in addition to customary fisheries, iwi owned fisheries often play a major role in the commercial fishing sector. Today iwi influence more than 30% of New Zealand's commercial fisheries (Maxwell, 2012).

Figure 22 Rohe Moana, Mataitai and Taiapure in the Vicinity of the Operational Area



4.5 Socio-economic Environment

This section focuses on the users of the environment within and in the vicinity of the Operational Area.

4.5.1 Recreational Fishing

The majority of the Operational Area is not often fished by recreational fishers due to its distance offshore (beyond the 12 Nm Territorial Sea), however, the inshore coastline of the Operational Area is utilised by recreational fishers, particularly around Kaikoura, Banks Peninsula, the south and southeast Wellington coast, and in Hawke's Bay.

The North Island's east coast from Cape Runaway in the north, south to Titahi Bay in western Wellington is classed as the 'Central East' fisheries region. Recreational use of this region is high, including high historic/traditional use which still continues. A number of sport fishing, surf casting and boating clubs are active in the region, with an influx of visiting recreational fishers in summer months. The Central East region is renowned for catches of recreational paua and rock lobster, as well as line fisheries for red gurnard, tarakihi, snapper, kingfish, hapuku and trevally. Butterfish, moki and kahawai are often caught by set-nets. Large migratory warm water pelagic fish move into the region in summer (MPI, 2016a).

The Southeast fishery region covers the remainder of the Operational Area, including the main fisheries areas at Kaikoura. Canterbury and Otago are also included in this fisheries region but are outside of the Operational Area. Kaikoura provides a range of recreational fishing including diving on the rocky reefs for paua, crayfish, and kina, to shore and boat fishing opportunities (MPI, 2016b).

4.5.2 Commercial Fishing

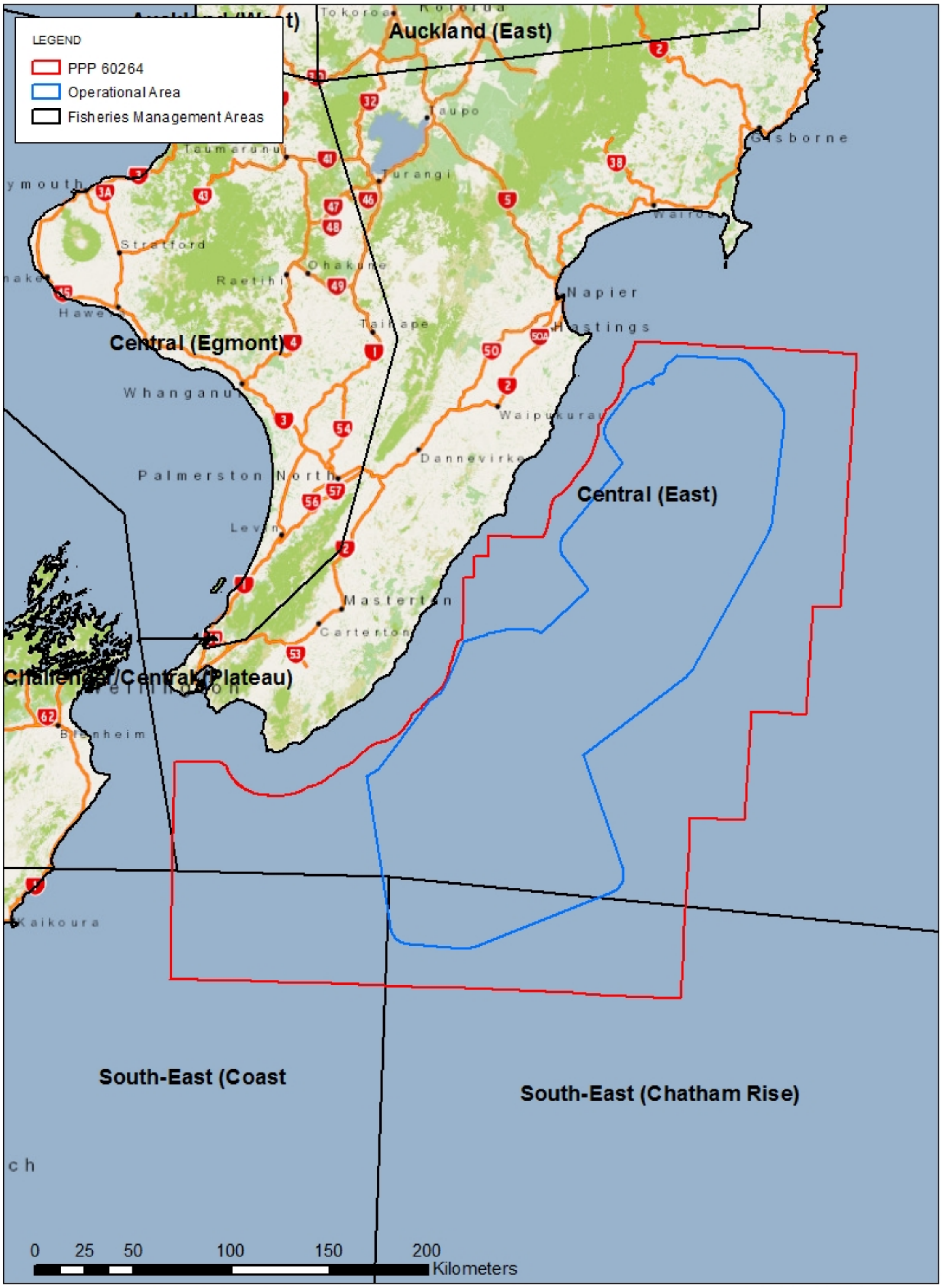
There are ten Fisheries Management Areas in New Zealand, implemented in order to manage the Quota Management System. The Operational Area falls within areas FMA2 (Central East), FMA3 (South-East Coast) and FMA4 (South-East Chatham Rise) (**Figure 23**). Fisheries Management Areas are regulated by the Ministry for Primary Industries. Over 1,000 species of fish occur in New Zealand waters (Te Ara, 2016h); with the Quota Management System providing for the commercial utilisation and sustainable catch of 96 species. Species managed under the Quota Management System are divided into separate 'stocks' (based on geographical distribution), with each stock managed independently.

The Ministry for Primary Industries has analysed the reported catch from commercial fisheries that started or ended in the Operational Area for the 2008/09 – 2012/13 fishing years. Each fishing year covers the period starting 1 October through to 30 September the following year.

Orange roughy, alfonsino, hoki, bluenose, and cardinalfish are the top five species commercially caught in the Operational Area (**Table 18**). 'Others' include all other fish species commercially caught within the Operational Area. The orange roughy fishery is annually the largest commercial fishery by weight in the Operational Area; with the exception of the 2009/10 fishing year, where alfonsino had the highest estimated catch (MPI, 2014).

Although the orange roughy fishery is the largest by weight, it is only the third largest commercial fishery with regard to the number of targeted events (**Table 19**). Scampi are the most targeted species in the Operational Area with 405 targeted fishing events, followed by bluenose, orange roughy, alfonsino, and then ling (MPI, 2014).

Figure 23 Fisheries Management Areas within New Zealand Waters



The most commonly used fishing method within the Operational Area is trawling, followed by bottom long-lining, and surface lining (**Table 20**). Trawl events peak between October and March with a second peak in September. Bottom long-lining occurs within the Operational Area year round, with a slight decrease in long-lining events in March. Surface long-lining in the Operational Area is restricted to between January and June. Overall, fishing events are greatest in the first half of the fishing year (October – March) compared to the second half. Bottom fishing is mainly carried out along the Territorial Sea boundary, while surface fishing effort is mainly concentrated in the northern to north-eastern sections of the Operational Area (MPI, 2014).

The Operational Area is fished by between 43 and 60 fishing vessels per year; however, the top ten vessels in terms of number of fishing events are responsible for up to 70% of the total number of events carried out in the Operational Area (MPI, 2014).

Table 18 Estimated Catch (in tonnes) of the Top Five Species During the 2008/09 - 2012/13 Fishing Years

Species	2008/09	2009/10	2010/11	2011/12	2012/13	Total
Orange roughy	570	489	624	403	373	2,459
Alfonsino	424	523	393	388	329	2,057
Hoki	100	117	464	63	158	903
Bluenose	254	317	114	113	73	871
Cardinalfish	313	212	103	39	16	684
Others	579	799	756	482	495	3,108
Total	2,239	2,458	2,455	1,488	1,441	10,082

Table 19 Number of Fishing Events by Target Species During the 2008/09 – 2013/13 Fishing Years

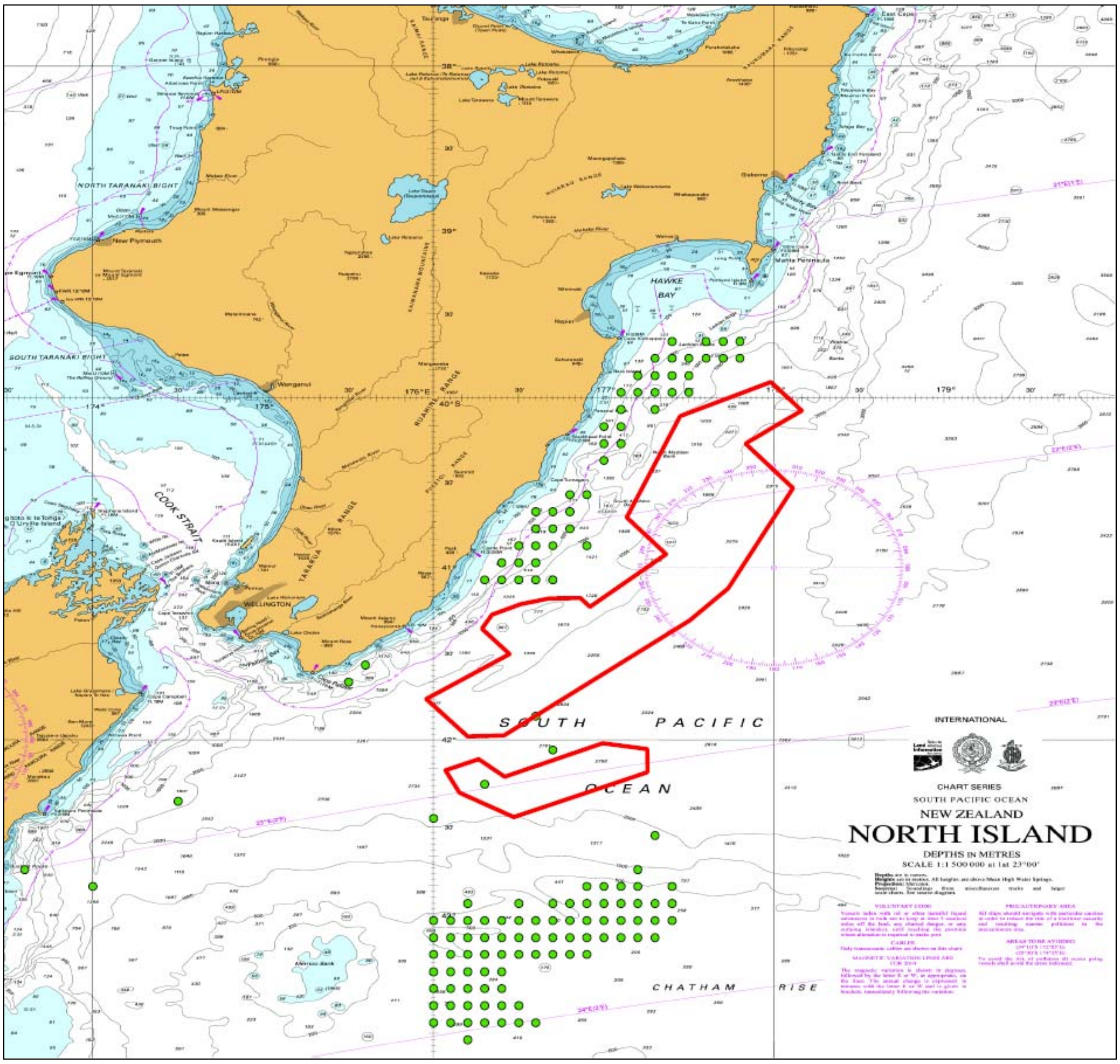
Target Species	2008/09	2009/10	2010/11	2011/12	2012/13	Total
Sampi	405	866	790	460	378	2,899
Bluenose	459	743	345	333	89	1,969
Orange roughy	260	254	248	136	179	1,077
Alfonsino	179	206	168	133	93	779
Ling	166	120	107	113	145	651
Others	347	455	395	222	220	1,639
Total	1,816	2,644	2,053	1,397	1,104	9,014

Table 20 Number of Fishing Events by Fishing Method During the 2008/09 - 2012/13 Fishing Years

Method	2008/09	2009/10	2010/11	2011/12	2012/13	Total
Trawl	1,158	1,648	1,542	844	799	5,991
Bottom longline	569	806	425	438	216	2,454
Surface longline	52	176	84	76	77	465
Other	37	14	2	39	12	104
Total	1,816	2,644	2,053	1,397	1,104	9,014

Discussions were held with the commercial scampi fishers and quota holders over concerns they had that the Pegasus seismic survey would influence the scampi fishery and their catch rates. A request was made to MPI for the last four years of data showing scampi fishing effort, where scampi trawls started, finished or passed through a 6km x 6 km block. The results have been overlaid with the survey area and is provided in **Figure 24**. The map clearly shows there is minimal overlap with the scampi fishing areas and those marks that are within the survey area are clearly errors within the data. As a result, the scampi fishers were comfortable with the seismic survey taking place and did not consider there would be any conflict.

Figure 24 Scampi Fishing Effort in Relation to Survey Area



The fisheries described in MPI (2014) are typically deep-water species. In addition to these species, commercial fisheries for inshore species also exist. Catch estimates for these species are not available therefore Total Allowable Commercial Catch (TACC) has been presented. It is important to note that the Operational Area is much smaller than the relevant FMAs combined; therefore TACC only provides an indication of the importance of commercial fisheries in the Operational Area, with regional variations not well represented.

According to TACC for the period September 2016 – September 2017, the top five inshore finfish species caught within FMA2, FMA3 and FMA4 are listed (**Table 21**)(MPI, 2016c).

Table 21 Total Allowable Commercial Catch Allocations for Inshore Finfish in the Operational Area

FMA2		FMA3		FMA4	
Species	**TACC (tonnes)**	**Species**	**TACC (tonnes)**	**Species**	**TACC (tonnes)**
Tarakihi	1796	Red cod	4600	Stargazer	2158
Alfonsino	1575	Rough skate[1]	4653	Sea perch	910
Flatfish[2]	726	Flatfish[3]	1430	Blue cod	759
Gurnard	726	Tarakihi	1403	Hapuku	323
Kahawai	705	Gurnard	1264	Tarakihi	316

In addition to the finfish species commercially targeted in FMA2, FMA3 and FMA4, significant shellfish and red rock lobster fisheries also exist.

The shellfish and invertebrate fishery of FMA2 extends from Titahi Bay on Wellington's west coast (outside of the Operational Area), across Wellington's south coast and then up the east coast to Cape Runaway. The top five shellfish species in FMA2 with regard to TACC are deepwater tuatua (4,660 tonne), triangle shells (1,250 tonne), paua (1,219 tonne), kina (95 tonne in a combination of East Coast, Wairarapa and Wellington stocks), and trough shells (63 tonne). Paddle crabs are also important with a TACC of 110 tonne (MPI, 2016c).

The shellfish fishery in FMA3 is a multi-stock fishery and includes species associated with sand and mud bottomed coastal areas out to the edge of the continental shelf. Approximately 1,437 tonnes of shellfish are taken annually from FMA3, mainly New Zealand littleneck clams and kina (MPI, 2016d).

The Operational Area covers the CRA3 (Gisborne/Hawke's Bay), CRA4 (Wellington/Hawke's Bay) and CRA5 (Canterbury/Marlborough) stocks for red rock lobster. The lower east coast of the North Island is considered to be particularly important for red rock lobster larvae. The TACC for each stock is provided in **Table 22** below; however, it is worth noting that a large proportion of the coastline in CRA3 is outside of the Operational Area.

Table 22 East Coast Red Rock Lobster Total Allowable Commercial Catch

Stock	TACC (tonnes)
CRA3 – Gisborne/Hawke's Bay	2,610
CRA4 – Wellington/Hawke's Bay	3,970
CRA5 – Canterbury/Marlborough	3,500

Within the Operational Area there is a nationally significant paua fishery along the Wairarapa coastline (managed under paua stock PAU2) and between Cape Campbell and Kaikoura (managed under paua stock PAU3). TACC for these stocks are 121 and 91 tonnes respectively. The majority of commercial paua catch is landed over summer months on account of the harvest of paua being limited to free diving.

Hoki and orange roughy are some of New Zealand's most economically valuable fisheries. Due to the high economic importance of these fisheries and the location of the Operational Area over some of the main fishing grounds (see **Figure 25**) further details on these fisheries have been briefly provided below.

[1] TACC for this species is based on a combined catch in FMA3, FMA4, FMA5, and FMA6
[2] TACC for this species is based on a combined catch in FMA 2 and FMA8
[3] TACC for this species is based on a combined catch in FMA3, FMA4, FMA5, and FMA6

The hoki fishery is New Zealand's largest finfish fishery (O'Driscoll & Ballara, 2014). The hoki bottom trawl fishery operates on the Chatham Rise throughout the year, although catch tends to decrease during the spawning season (July to September) (O'Driscoll & Ballara, 2014). There are four known hoki spawning grounds, two of which occur in the Operational Area; the Cook Strait and east coast south island (off Banks Peninsula) spawning grounds. Hoki are divided into an 'east' and 'west' stock based on their spawning ground; the western stock is resident in the Southern Plateau and spawns on the west coast, while the eastern stock is resident on the Chatham Rise and spawns on the east coast and in Cook Strait. Juveniles from both stocks mix together on the Chatham Rise before recruiting to their respective stocks at sexual maturity (O'Driscoll & Ballara, 2014). The highest catch rate of hoki occurs on the western Chatham Rise (O'Driscoll & Ballara, 2014). Quota for hoki is set annually based on an estimated stock size and as a result hoki quota fluctuates through time.

Orange roughy are caught year round by commercial bottom trawlers, with peak catch occurring during the spawning season in June and early August (SeaFic, 2016). The orange roughy fishery is one of New Zealand's most valuable fisher, with 2014 exports generating $36 million for the New Zealand economy (MPI, 2016e). The Operational Area overlaps with four recognised orange roughy management areas; ORH2A, ORH2B, ORH3A and ORH3B (**Figure 25**).

The Wairarapa/Hawke's Bay coast is also important to the commercial scampi fishery, particularly the North and South Madden Banks (Deepwater Group, 2016). The scampi fishery typically operates over the continental slope in water depths of 300 – 500 m (MPI, 2014). Scampi spawn in early spring/summer, and it is during these life stages that the greatest volume of catch is made. The Operational Area extends over scampi stocks SCI2 (Central East) and SCI3 (South East Coast and Western Chatham Island). TACC for these stocks is 133 and 340 tonnes, respectively. The scampi fishery results in a large proportion of bycatch, with scampi catch typically representing less than 20% of the catch by weight (Ballara & Anderson, 2009). Bycatch is comprised of quota species (e.g. sea perch, ling, hoki and red cod) and non-quota species (e.g. rattails, dogfish and skate) which are discarded (MPI, 2014; Ballara & Anderson, 2009).

Consultation with Rangitane has identified king crabs as a potential under-developed fishery in the Pegasus Basin. King crabs were introduced to the Quota Management System on 1 April 2004. They are commercially targeted by potting; however, king crabs are also caught (and discarded) as by-catch in the orange roughy fishery off the Wairarapa Coast and in the Queen scallop dredge fishery off Otago (MPI, 2016f). The Operational Area covers the king crab stocks KIC2 (Central East), KIC3 (South-East Coast) and KIC4 (Chatham Rise). Catch peaks vary between stocks, peaking in September within KIC2 and December to February in KIC4. The highest commercial catch occurs within KIC3 where crabs are caught year round, with catch peaking in February (MPI, 2016f). There is no allowance for customary or recreational catch of king crabs.

Consultation has been undertaken with the deepwater fishers that utilise the waters within and surrounding the Operaional Area to advise them of the proposed seismic operations and the span of gear that will be used. A summary of engagements is provided in **Appendix B**. These groups will be provided with contact details of the vessel closer to the commencement date and will have access to web-based real-time updates of the seismic vessel's position.

Figure 25 Hoki (Left) and Orange Roughy (Right) Fishing Grounds

Source: Deepwater Group, 2016: http://deepwatergroup.org/

4.5.3 Commercial Shipping

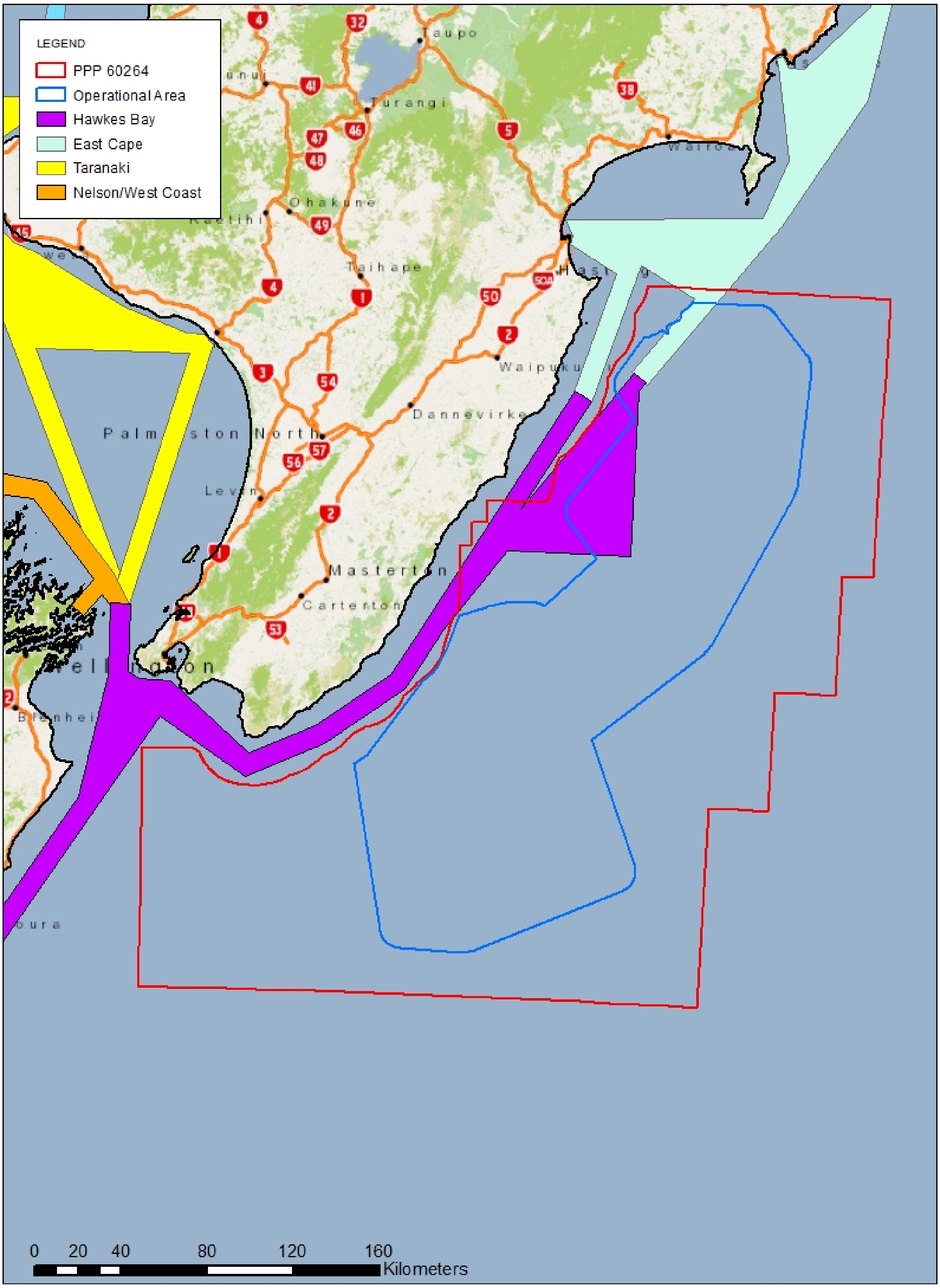
Napier Port, and CentrePort Wellington are the closest ports to the Operational Area.

Napier Port is the most northern port of relevance to the Operational Area. It is located at the city of Napier, Hakwe's Bay. Napier Port is the North Island's second largest export port by tonnage and the fourth largest container terminal. Napier Port has a maximum vessel draft of 12.4 m and can routinely handle vessels up to 311 m in length. Forestry products, processed fruit and vegetables, dairy, and meat are the main exports out of this port. Napier Port supports international vessels including overseas cargo/export and cruise ships (NapierPort, 2016).

CentrePort Wellington is said to be in the heart of New Zealand's freight and transport system due to its location in Wellington; the capital of New Zealand. The port is located in the naturally sheltered, deepwater Wellington Harbour and provides modern port facilities for cargo/export and cruise ships, as well as a terminal for the Cook Strait ferry. CentrePort Wellington has two berths that can accommodate vessels with up to 11 m draft (no limit on length) as well as 21 general cargo berths. Major cargo handled at CentrePort Wellington includes forestry products (logs, veneer, and pulp), petrol and chemicals, cement, wheat, fruit, and vehicles (CentrePort, 2016).

There are no dedicated shipping lanes between New Zealand ports; commercial shipping vessels will take the shortest route with consideration of the weather conditions and most current forecast. The general shipping routes between the New Zealand ports of relevance to the Operational Area are shown in **Figure 26**.

Figure 26 General shipping routes in the Operational Area



5 POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION MEASURES

This section presents an overview of the potential environmental effects that may arise from the operation of the Pegasus Basin Seismic Survey. Effects could potentially occur either under normal operating situations (planned activities) or during an accidental incident (unplanned event). Proposed mitigation measures are also provided throughout this section.

An Environmental Risk Assessment (ERA) has been undertaken using a risk matrix to identify the significance of each potential effect based on a likelihood and consequence approach (**Table 23**). The joint Australian & NZ International Standard Risk Management – Principles and Guidelines, (ASNZS ISO 31000:2009) has been used to develop the ERA. These guidelines define risk as 'the uncertainty upon objectives', while the effect is a deviation from the expected – either positive or negative. This assessment considers the consequence (**Table 24**) and likelihood (**Table 25**) of each potential environmental effect, including its geographical scale and duration. A description of the risk categories is provided in **Table 26.**

The ERA methodology is undertaken based on the assumption that the proposed mitigation measures to avoid remedy or mitigate environmental effects are in place. Hence, risk determination is made for any residual effect that may still occur despite the use of mitigation measures.

The main steps used in the Environmental Risk Assessment are:

- Identification of the sources of potential effects;
- Description of potential effects;
- Identification of potential environmental receptors and their sensitivity to potential effects;
- Development of measures to avoid, remedy or mitigate each potential effect; and
- Determine the risk associated with any residual effects (in accordance with **Table 23, Table 24** and **Table 25**).

Table 23 Environmental Risk Assessment Matrix

		Consequence of Effect				
		0 - Negligible	**1 - Minor**	**2 - Moderate**	**3 - Major**	**4 - Catastrophic**
Likelihood of Effect	**1 - Rare**	Low (0)	Low (1)	Low (2)	Medium (3)	Medium (4)
	2 - Unlikely	Low (0)	Low (2)	Medium (4)	Medium (6)	High (8)
	3 - Possible	Low (0)	Medium (3)	Medium (6)	High (9)	High (12)
	4 - Occasional	Low (0)	Medium (4)	High (8)	High (12)	Extreme (16)
	5 - Likely	Low (0)	Medium (5)	High (10)	Extreme (15)	Extreme (20)

Note: Numerical values in brackets are the 'risk score'; the product of the 'consequence' and 'likelihood' scores

Table 24 Consequence Definitions for Residual Effects

Consequence level (consequence score)	**Underwater noise**	**Populations**	**Magnitude & Recovery Period**	**Proportion of habitat affected**	**Existing Interests (fisheries – commercial or recreational, cultural, social, shipping etc.)**
4 - Catastrophic	Species of concern exposed to SELs greater than 218 dB re 1μPa^2.s (could elicit permanent threshold shift)	Severe impact to communities and populations. Local extinctions likely.	Large scale effect (11-100 km^2). Long term duration (years). No recovery predicted	Activity will result in major changes to ecosystem or region. Virtually all available habitat is affected.	Long term and wide scale disruptions to normal activities.
3 - Major	Other marine mammals (i.e. not species of concern) exposed to SELs greater than 218 dB re 1μPa^2.s (could elicit permanent threshold shift)	Long-term impact to communities and populations. Threatens long-term viability.	Large scale effect (11-100 km^2). Long term duration (years). Substantial recovery period required once activity stops (more than a month).	Activity may result in major changes to ecosystem or region; 61-90% of habitat affected.	Long term disruptions to normal activities.
2 - Moderate	Marine mammals exposed to SELs between 186 and 218[4] dB re 1μPa^2.s (could elicit temporary threshold shift)	Medium-term impact to communities and populations. Could affect seasonal recruitment, but does not threaten long-term viability.	Medium scale effect (1-10 km^2). Medium term duration (weeks-months). Short term recovery period required once activity stops (days to weeks).	Potential adverse effects more widespread; 21-60% of habitat is affected.	Medium term disruptions to normal activities.
1 - Minor	Marine mammals exposed to SELs between 171 and 186 dB re 1μPa^2.s (could elicit a behavioural response)	Short-term impact to communities and populations. Does not threaten viability.	Localised effect (<1 km^2). Short term duration (weeks). Rapid recovery would occur once activity stops (within hours-days).	Measurable but localised; potential effects are slightly more widespread; 6-20% of habitat area is affected.	Short term disruptions to normal activities.
0 – Negligible	Marine mammals exposed to SELs less than 171 dB re 1μPa^2.s	No detectable adverse effects to communities or populations.	Highly localised effect (immediate area). Temporary duration (days). No recovery period necessary	Measurable but localised, affecting 1-5% of area of original habitat area.	No disruptions to normal activities.

[4] Permanent threshold shift in marine mammal hearing is thought to occur between 218 – 230 dB re 1 μPa^2-s (Southall *et al.*, 2007).

Table 25 'Likelihood' Definitions for Residual Effects

Likelihood (likelihood score)	**Definition**
5 - Likely	Expected to occur (potentially continuous or multiple times)
4 - Occasional	May occur occasionally
3 - Possible	Could possibly occur
2 - Unlikely	Has been known to occur
1 - Rare	Could only occur in exceptional circumstances

Table 26 Risk Category Definitions for Residual Effects

	Extreme Risk: (15 - 20)	Risk is unacceptable and project redesign is recommended. Effects on marine fauna or existing interests would be severe and unavoidable. Recovery may not occur.
	High Risk: (8 - 12)	Additional mitigation measures must be considered before operations commence. Effects on marine fauna or existing interests are significant and a long recovery time may be required.
	Medium Risk: (3 - 6)	No additional mitigation actions required for short-term operations, but long-term operations should consider additional mitigation measures. Some effects on marine fauna (e.g. behavioural response or masking) or existing interests (displacement) are expected.
	Low Risk: (0 - 2)	No regulatory violation or requirement for additional mitigation actions anticipated. No significant effects on marine fauna or existing interests are expected.

Note: Numerical values in brackets are the 'risk score'

Table 27 summarises the sources and potential effects that could occur from planned activities during the Pegasus Basin Seismic Survey. These potential effects, their proposed mitigations and the associated ERA results are described in detail through the remainder of this section. The Potential effects from unplanned events are also discussed at the conclusion of this section.

Table 27 Potential Sources of Effect Associated with Planned Activities

Source	**Potential Effects**
Presence of seismic vessel and towed gear	• Displacement of marine fauna or existing interests • Marine mammal ship strike or entanglement • Seabird collision
Acoustic disturbance to the marine environment	• Behavioural effects (changes in distribution or disruption) • Physiological effects (threshold shift or injury) • Perceptual effects (masking of biological sounds)
Vessel discharges & emissions	• Biodegradable waste pollution • Atmospheric pollution

5.1 Planned Activities – Potential Effects and Mitigations

5.1.1 Presence of seismic vessel and towed equipment

The physical presence of the survey vessels and the towed span of associated acoustic equipment have the potential to effect marine fauna and some existing interests. Each potential effect is discussed in the following sub-sections.

5.1.1.1 Potential effects on marine mammals

Vessel presence has the potential to affect marine mammals in four primary ways: 1) Disruption of normal behaviour; 2) Displacement of individuals from habitat; 3) Ship strikes - collision between a marine mammal and vessel; and 4) Entanglement risks associated with towed equipment.

The disruption of normal behaviour and displacement from an area is of particular concern when these changes occur frequently over a prolonged period and/or when they affect critical behaviours (i.e. feeding, breeding and resting). Although there is potential for the physical presence of the survey vessels and associated acoustic equipment to cause some changes in marine mammal behaviours and/or displacement from habitat, such disturbance is predicted to be temporary and localised during the Pegasus Basin Seismic Survey. In addition, in order to be affected by the presence of the survey vessels and associated equipment, a marine mammal must first be in close proximity while the seismic vessel is acquiring.

An emerging global concern is the collision of marine mammals and vessels. This is commonly referred to as ‘ship strike’. Jensen & Silber (2003) reviewed the global database of ship strike incidents. This study considered a total of 292 records of ship strike and identified 11 different species that were at a high risk, with fin whales (75 records) and humpback whales (44 records) the most commonly implicated species. Of the high risk species identified in the Jensen and Silber (2003) study, it is considered that nine could potentially be present within the Operational Area: Bryde’s whales, blue whales, fin whales, humpback whales, killer whales, minke whales, sei whales, southern right whales, and sperm whales.

During a ship strike incident, vessel type also affects the likelihood of mortality. Navy vessels and container/cargo ships/freighters are involved in the majority of fatal ship strikes: with records indicating that seismic vessels have only been responsible for one known fatality globally since records began in the late 1800s (Jensen & Silber, 2003). Records of sub-lethal effects are less reliable on account of the difficulty in assessing injury in free swimming cetaceans following a collision.

Perhaps the primary contributing factor that dictates the severity of a ship strike incident is the speed of the vessel; with likelihood of mortality increasing with increasing vessel speed. Jensen & Silber (2003) reported that the mean vessel speed that resulted in mortality during a ship strike was 18.6 knots. The typical speed of a seismic vessel during acquisition is ~4.5 knots; less than four times slower than the mean fatal speed reported by Jensen & Silber (2003).

It is possible that marine mammals could interact with and become entangled in the towed seismic equipment; however, this is highly unlikely to occur on account on marine mammals displaying exceptional abilities to detect and avoid obstacles in the water column and the lack of loose surface lines associated with the towed equipment. Marine mammals are known to interact with fishing gear; however, a point of difference with seismic surveys is that there is no food attractant involved (i.e. bait or catch). To our knowledge, there has never been a reported case of a marine mammal becoming entangled in seismic equipment.

In accordance with the Code of Conduct, MMOs will be on-watch during daylight hours for all periods of acquisition during the Pegasus Basin Seismic Survey. In addition to this, at least one MMO will be stationed on the bridge during good weather while the seismic vessel is in transit to and from the Operational Area in order to maximise the marine mammal data collected during the survey. The Marine Mammal Mitigation Plan (MMMP) outlines the protocol that MMOs will following during the Pegasus Basin Seismic Survey; this is included as **Appendix E**.

In addition, MMOs will be vigilant for marine mammal entanglements, will be expected to report any dead marine mammals observed at sea, and will notify DOC immediately should any live sightings of Hector's/Maui's dolphins be made. MMOs will provide weekly reports to DOC and the Environmental Protection Authority.

Given the information detailed above, it is considered that the risk to marine mammals arising from the physical presence of the survey vessels and towed equipment during the Pegasus Basin Seismic Survey is ***medium*** (minor x likely).

5.1.1.2 Potential effects on seabirds

A high number of seabirds are likely to be present within the Operational Area (see **Section 4.2.7**), which increases the likelihood of an encounter between seabirds and the seismic vessel during the Pegasus Basin Seismic Survey. Seabirds frequently interact with vessels at sea, and while many of these interactions are harmless, such as the provision of perching opportunities that would otherwise not be available, some interactions can lead to injury or death (i.e. collision or entanglement in vessel rigging, particularly at night). Seabirds flying at night can become disorientated as a result of artificial lighting, and this is particularly the case for fledglings and novice flyers in coastal locations (Telfer *et al.*, 1987). The use of artificial lighting on-board a vessel can increase the risk of seabird collisions (Black, 2005).

Behavioural observations of seabirds around seismic operations are limited. However, bird counts and distributional analyses of shorebirds and waterfowl from the Wadden Sea (an intertidal zone of the North Sea) showed no significant change as a result of a seismic survey, although a trend for temporary avoidance within a 1 km radius of the seismic vessel was observed (Webb & Kempf, 1998).

Even though no specific mitigations are in place to reduce the likelihood of a collision between seabirds and the survey vessels, the vessels used in the Pegasus Basin Seismic Survey confer no greater collision threat than any other vessel in the area would. Furthermore, the slow operational speed of the vessels reduces any potential for detrimental interactions; in fact the presence of the seismic vessel could provide a resting place for seabirds that would otherwise be unavailable. The short-term duration of the survey limits the temporal scale of potential effects (both negative and positive).

Diving seabirds in close proximity to the acoustic source are unlikely to be engaged in active foraging as most small pelagic fish species that would be potential prey are expected to avoid the immediate area surrounding the seismic vessel and towed equipment.

In summary, the risk to seabirds from the physical presence of the seismic vessel, support vessel and the towed equipment is considered to be ***low*** (negligible x likely).

5.1.1.3 Potential effects on fisheries and marine traffic

The Pegasus Basin Seismic Survey could potentially interfere with commercial fishing activities by causing a temporary displacement of fishing operations as the survey passes through fishing grounds within the Operational Area. Seismic data acquisition could also cause displacement of fish stocks; however, such effects will be strictly temporary on account of the short term nature of seismic operations.

Likewise, other marine traffic that transits through the Operational Area may be required to change course slightly to avoid the seismic survey operations.

Commercial users have been advised of Schlumberger's proposed operations and will be kept informed with regard to survey commencement dates and progress. Although it is assumed that any potential effects will be temporary, Schlumberger will undertake the following mitigation measures to further minimise any effects:

- Seismic operations will occur 24 hours a day, 7 days a week (weather and marine mammal encounters permitting) to minimise the overall duration of the survey;

- The survey vessels will comply with the COLREGS (e.g. radio contact, day shapes, navigation lights, etc);
- A support vessel will be present;
- Schlumberger will issue a Notice to Mariners and a coastal navigation warning will be broadcast on marine radio; and
- A tail buoy with lights and radar reflector will be displayed at the end of each streamer to mark the overall extent of the towed equipment.

With the above mitigation measures in place, the environmental risk to any fishing vessels or other marine traffic is considered to be ***medium*** (minor x likely).

5.1.1.4 Potential effects on marine archaeology, cultural heritage or submarine infrastructure

Physical effects on marine archaeology, cultural heritage or submarine infrastructure would typically only occur if the towed equipment were to come into contact with the seabed. During normal seismic operations there is no intention for this to occur, therefore no effects are predicted. The loss of equipment during an unplanned incident is further discussed in **Section 5.2.2**.

Areas of archaeological interest or cultural significance are typically associated with intertidal and subtidal coastal environments, instead of offshore areas like those in the Operational Area. As the Pegasus Basin Seismic Survey will occur outside the territorial sea, the potential for interactions with marine archaeology and cultural heritage is minimised.

It is considered that the potential interference with any marine archaeology, cultural heritage, or submarine infrastructure is ***low*** (negligible x unlikely).

5.1.2 Acoustic disturbance to the marine environment

During a seismic survey the level of lateral attenuation varies with propagation conditions; in good propagation conditions, noise will travel further and background noise levels may not be reached for >100 km, while in poor propagation conditions, background levels can be reached within a few tens of kilometres (McCauley, 1994).

The acoustic pulse from the seismic source produces a steep-fronted wave that is transformed into a high-intensity pressure wave; a shock wave with an outward flow of energy in the form of water movement. The result is an instantaneous rise in maximum pressure, followed by an exponential drop in pressure. The environmental effects on an animal in the vicinity of a sound source are defined by individual interactions with these waves.

In general, a high intensity acoustic disturbance will cause a behavioural response in animals (typically avoidance or a change in behaviour). The nature (continuous or pulsed) and intensity of the noise, as well as the species, gender, reproductive status, health and age of an animal influences the duration and intensity of the animal's observed response.

A behavioural response is an instinctive survival mechanism that serves to protect an animal from injury. Animals may suffer temporary or permanent physiological effects in cases when the external stimulus (e.g. acoustic disturbance) is too high or the animal is unable to elicit a sufficient behavioural response (e.g. move away fast enough).

The potential effects of acoustic disturbance can include:

- Behavioural changes and related effects such as displacement, disruption of feeding, breeding or nursery activities;
- Perceptual effects such as interference with communications and masking of biologically important sounds; or

- Physiological effects such as changes in hearing thresholds, damage to sensory organs, or traumatic injury.

Indirect effects are also possible and could lead to ecosystem level effects, for example behavioural changes in prey species that affects their accessibility to predators.

DOC developed the Code of Conduct as a tool to specifically minimise the potential effects of acoustic disturbances from seismic surveys, particularly with regard to behavioural and physiological effects. Complying with the Code of Conduct is the primary way in which potential acoustic effects from the Pegasus Basin Seismic Survey will be managed.

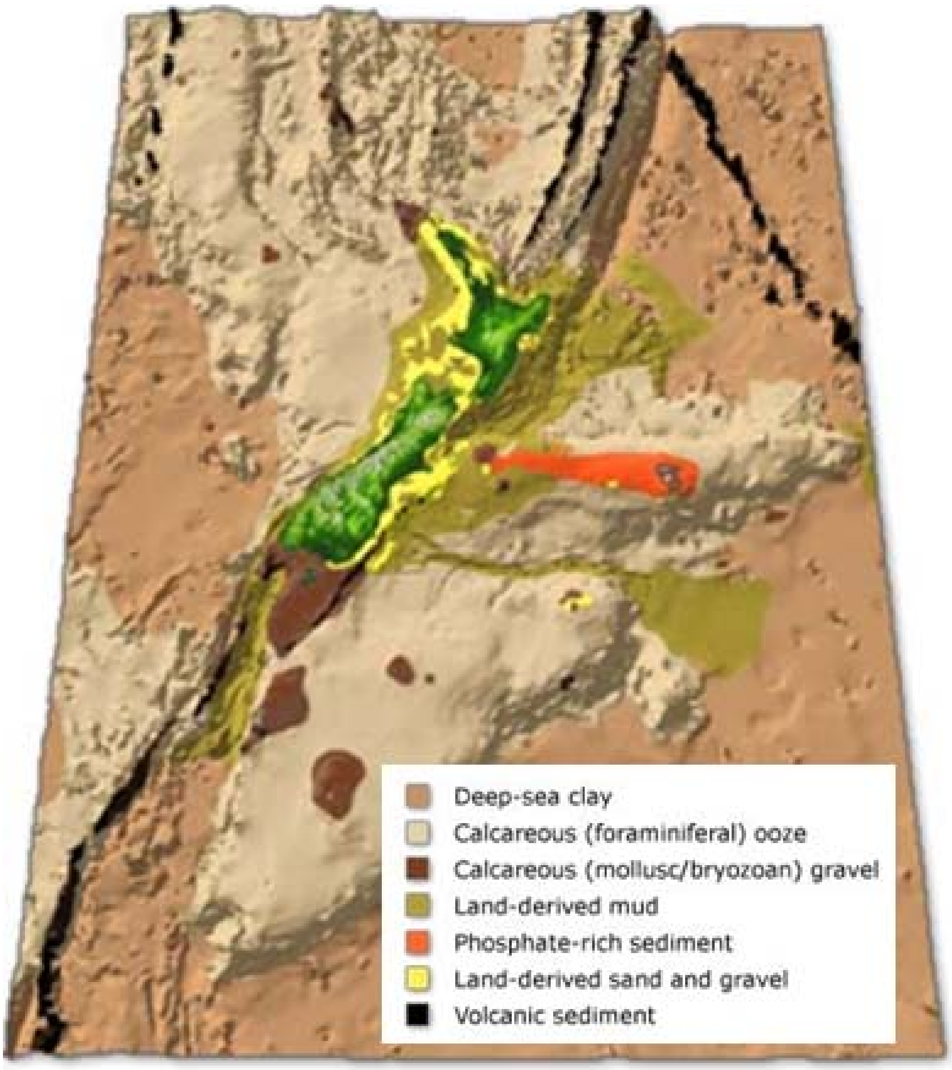
Potential acoustic exposure of marine fauna during the Pegasus Basin Seismic Survey was assessed by STLM. STLM uses input parameters specific to the source array, and bathymetry data of the Operational Area. This modelling is required by the Code of Conduct for surveys that will occur within an Area of Ecological Importance (see **Section 3.5.3**). The results of the STLM are presented below.

5.1.2.1 Sound Transmission Loss Modelling

STLM was conducted to predict received SELs from the Pegasus Basin Seismic Survey to assess for compliance with the mitigation zones outlined in the Code of Conduct (short-range modelling) and to predict sound propagation into sensitive areas (long-range modelling). The modelling methodology addressed both the horizontal and vertical directionality of the acoustic array and considered the different water depths and substrate types found throughout the Operational Area. The complete modelling report is provided in **Appendix C**.

The Operational Area is relatively large and encompasses a range of bathymetry and seabed substrate types which represent ‘geo-acoustic regions’. The Continental Shelf around NZ is covered mainly with land-derived sand, gravel and mud sediment (**Figure 27**).

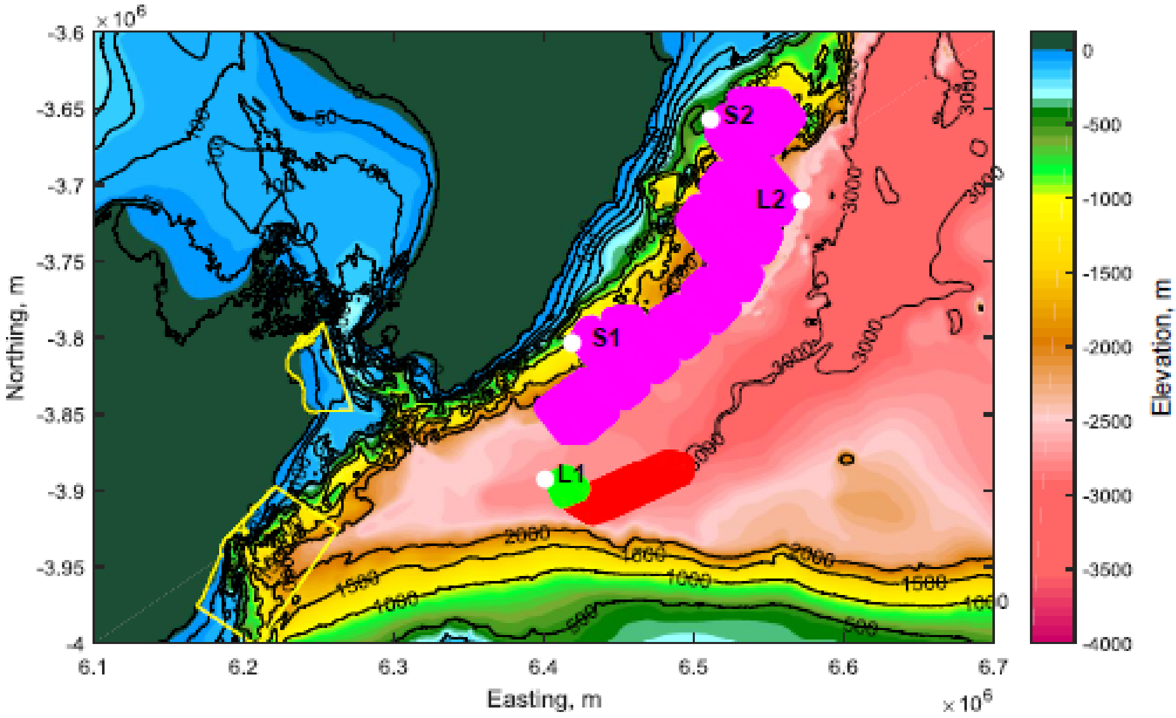
Figure 27 A Summary of Geo-acoustic Regions of New Zealand



In order to predict the highest SELs possible during the Pegasus Basin Seismic Survey, a number of modelling locations and conditions were selected. These locations were selected to represent worst case scenario of the sound propagation and are described as follows:

- Location S1 was selected for the short-range modelling as it represents the shallowest water depth in the northern part of the Operational Area (900 m) (**Figure 28**);
- Location S2 was also selected for short-range modelling as it represents the shallowest water depth in the southern part of the Operational Area (400 m) (**Figure 28**);
- Location L1 was selected for the long-range modelling because of its proximity to the Clifford and Cloudy Bay Marine Mammal Sanctuary as well as the Kaikoura Whale Sanctuary. The water depth at this location is 2,730 m (**Figure 28**);
- Location L2 was also selected for long-range modelling to consider noise propagation exposure to the deep water regions in the northeast of the Operational Area. The water depth at this location is 2,750 m (**Figure 28**);
- An autumn sound speed profile; and
- A silt seabed.

Figure 28: Short- and long-range modelling locations for the Operational Area



(Three discrete acquisition areas are shown in pink, green and red. The boundaries of protected areas are shown with a yellow outline.)

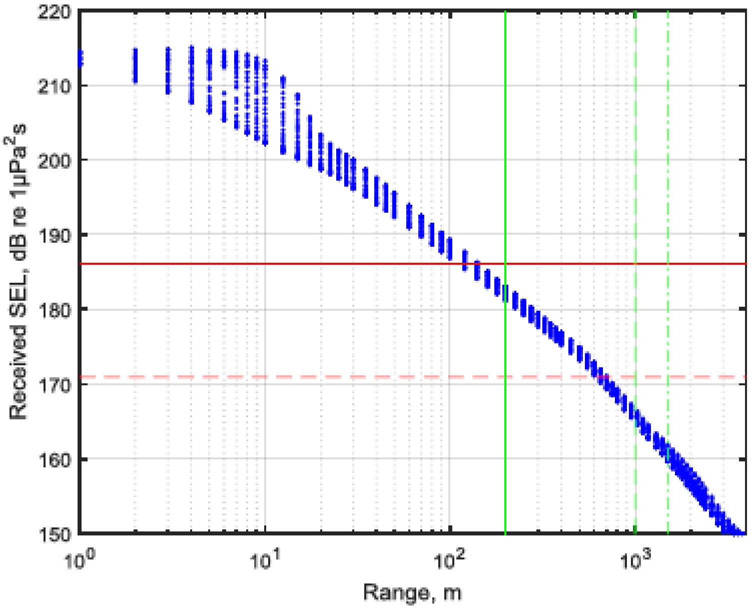
Short range modelling results

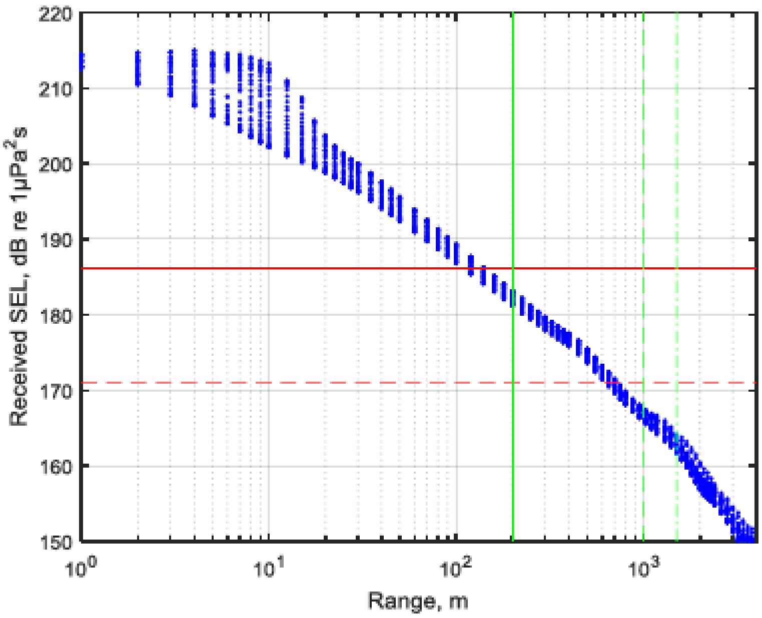
Short range modelling allows for predictions to be made about the likelihood of compliance with the standard Code of Conduct mitigation zones. For both locations S1 and S2, the model results predicted that the maximum SELs would comply with the thresholds for both physiological disturbance (186 dB re 1 μPa^2-s) and behavioural disturbance (171 dB re 1 μPa^2-s) at the standard Code of Conduct mitigation zones (i.e. 200 m, 1,000 m, and 1,500 m) (**Figure 29**). On this basis, Sclumberger proposes to use the following mitigation zones for the Pegasus Basin Seismic Survey:

- Proposed mitigation zone to satisfy physiological threshold = 200 m;
- Proposed mitigation zone to satisfy behavioural threshold for Species of Concern = 1,000 m (1 km); and
- Proposed mitigation zone to satisfy behavioural threshold for Species of Concern with calves = 1,500 m (1.5 km).

The short-range modelling concludes that although the volume of the seismic source array is comparatively large, the deep water depths within the Operational Area (minimum 400 m) and relatively weak directivities of the source array result in energy emissions from the source dissipating more evenly over the water column.

Figure 29 Predicted Maximum SELs from the 5,085 in³ Acoustic Source at Locations S1 (top image) and S2 (bottom image)





(For all azimuths as a function of range from the centre of the source array; solid red line = the physiological threshold; dashed red line = behavioural threshold; solid green line = 200 m from source, dashed green line = 1000 m from source; dot-dash green line = 1500 m from source)

Long range modelling results

Long-range modelling predicted that the received noise levels at far-field locations vary at different angles and distances from the source locations. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations. **Figure 30** presents the modelled SELs with range and depth along the cross-line and in-lin directions for both source locations L1 and L2.

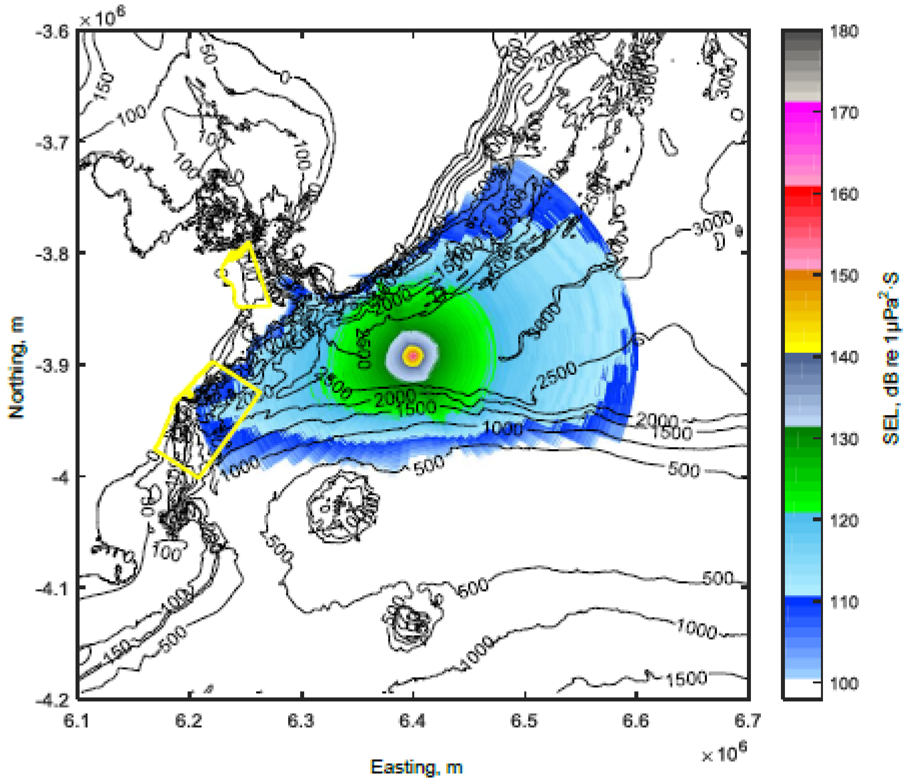
For both long-range source locations, significantly higher noise attenuations are predicted for the propagation paths with upslope bathymetry profiles, particularly for the directions towards the continental slope sections, due to the stronger interaction between the sound signal and seabed. The paths towards deep water regions tend to favour the noise propagation, with received noise levels predicted to 110 dB re 1μPa^2·s at a distance of 200 km from the two source locations.

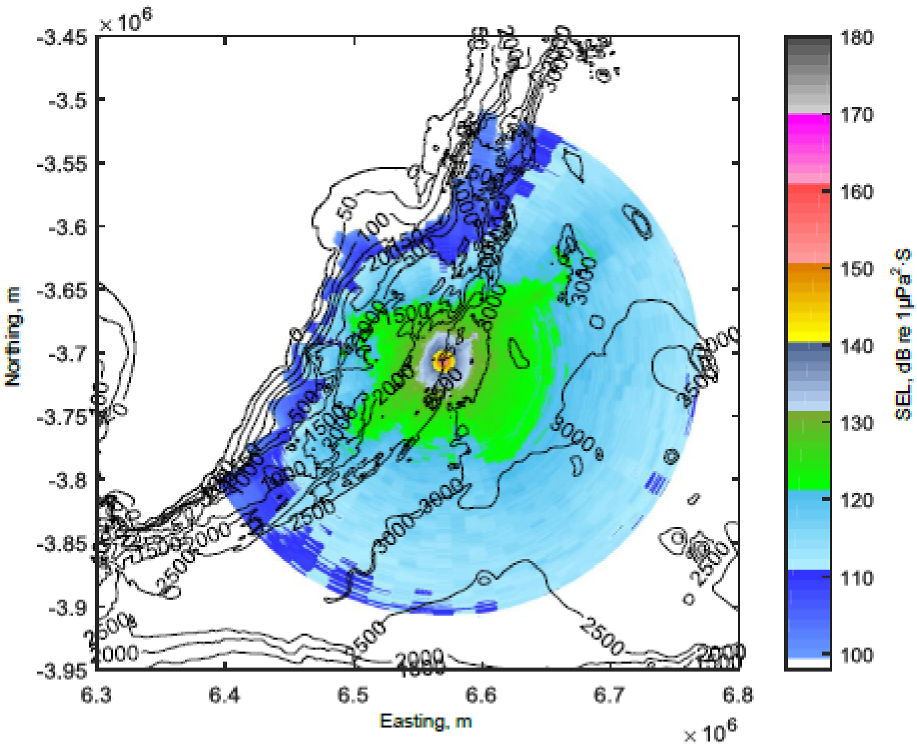
The boundary of the Clifford and Cloudy Bay Marine Mammal Sanctuary is approximately 150 km from the source location L1. The received noise levels within the Clifford and Cloudy Bay Marine Mammal Sanctuary from the source location L1 are predicted to be below 100 dB re 1μPa^2·s; well below both the thresholds defined by the Code of Conduct. These results indicate that marine mammals within the sanctuary are not expected to be subject to either behavioural or physiological disturbance.

The received noise levels within the Kaikoura Whale Sanctuary from the source location L1 are predicted to be 115 dB re 1μPa^2·s. This is also well below both the behavioural or physiological thresholds defined by the Code of Conduct.

At the nearest 12 nautical miles offshore boundaries to the two long-range source locations, the received noise levels are predicted to be 120 dB re 1μPa^2·s for source location L1 and 110 dB re 1μPa^2·s for source location L2 respectively.

Figure 30 Maximum SELs Predicted from the Source Locations L1 (top image) and L2 (bottom image) over a Range of 200 km





5.1.2.2 Potential behavioural effects on marine fauna

Perhaps the most well recognised behavioural response to seismic surveys is an avoidance response whereby animals are temporarily displaced from the area of seismic operations. While short-term displacement is thought to have very limited or no long-term implications for a population, any long-term displacement could lead to an animal relocating to sub-optimal or high-risk habitats. Long-term displacement can therefore result in negative consequences such as an increase in exposure to predators or decreased foraging or mating opportunities. Should any distributional changes occur as a result of the Pegasus Basin Seismic Survey, these will be strictly temporary and will only last for the expected duration of the survey.

The potential behavioural effects for each faunal grouping are discussed below.

Marine mammals

The most commonly documented behavioural responses from marine mammals in the vicinity of seismic surveys are avoidance, changes in vocal behaviour and changes in dive behaviour.

Avoidance of active seismic operations has been reported for many species of marine mammals (e.g. Dunlop *et al.,* 2016; Thompson *et al.*, 2013; Koski *et al.,* 2009; Weir, 2008; Johnson *et al.,* 2007; Potter *et al.,* 2007; Stone and Tasker, 2006; Goold, 1996). A review of 201 seismic surveys within UK waters concluded that most odontocetes were likely to exhibit a clear lateral avoidance response, while mysticetes demonstrated a more moderated response (Stone and Tasker, 2006).

An increase in surface behaviours has also been recorded from marine mammals in the vicinity of seismic surveys (McCauley *et al.*, 1998; McCauley *et al.*, 2003). This observation has been interpreted as a means of avoiding underwater noise on account of the 'Lloyd mirror effect' (Carey, 2009) which significantly reduces sound intensity in the upper-most part of the water column.

Below are examples of avoidance responses from different species.

- Humpback whales exposed to 160 – 170 dB re 1 µPa (peak to peak) sounds from seismic surveys consistently changed their course and speed to avoid any close encounters with the seismic array (McCauley *et al*., 2003);
- Thompson *et al.* (2013) found that displacement of harbour porpoises was observed when the study animals were exposed to peak-to-peak sound pressure levels of 165-175 dB re 1 µPa (a 470 in^3 acoustic source over ranges of 5 – 10 km). For harbour porpoises, displacement was temporary, with the animals detected again at affected sites within a few hours of exposure and a degree of habituation towards the sound source was also observed, with the level of response declining throughout the 10 day survey period (Thompson *et al*., 2013); and
- The effects of a seismic survey on the migratory behaviour of bowhead whales were documented by Richardson *et al.* (1995), with evidence found for a 20 – 30 km avoidance zone around the seismic vessel. Subsequent to this study further work has been done on bowhead whales to suggest that the rate of response is dependent upon the received sound levels. Blackwell *et al.,* (2015) documented changes in calling rates to demonstrate this; however the authors postulated that this effect was likely to apply to other behavioural changes (e.g. distribution) as well. Displacement of migrating whales is unlikely to have significant energetic consequences for when individuals are travelling in open seas, but could have a significant effect should displacement occur in confined waterways.

By displaying avoidance behaviours towards an approaching seismic vessel, marine mammals may be forced to leave valuable feeding or breeding grounds. Any deviation from their natural distribution and away from prey aggregations could result in an increase in the energy required to successfully capture prey. Consequences of displacement are predicted to have the greatest effect on species with restricted home ranges (Forney *et al*., 2013).

Likewise, in many circumstances the distribution of marine mammals is linked to that of their prey (see Fielder *et al*., 1998). Not only can seismic surveys affect the distribution of marine mammals, but prey distribution may also change. Indirect effects on marine mammals from changes in prey distribution include an increase in energy expenditure during foraging bouts in order to detect and capture prey, or a decrease in foraging success as a prey source in responding to seismic survey noise may no longer be available to marine mammals.

Some disruption to breeding behaviours could also result from displacement effects, although potential reproductive effects are managed to some extent by the mitigation zones imposed around the seismic vessel.

In addition to avoidance behaviours, some cetacean species are attracted to seismic operations; for instance Wursig *et al.* (1998) found that 88% of bottlenose dolphin groups in the Gulf of Mexico approached operating seismic vessels. NZ fur seals may also approach operating seismic vessels from time to time (Lalas & McConnell, 2016).

Changes in vocal behaviour in response to seismic surveys have also been documented. Examples include:

- Cerchio *et al.* (2014) documented a significant decrease in the number of 'singers' (associated with breeding behaviour) in a humpback whale population off Northern Angola during seismic surveys;
- Pirotta *et al.* (2014) documented that the buzz rate (associated with feeding behaviour) of harbour porpoises decreased during a seismic survey;
- Di Iorio and Clark (2010) documented an increase in the rate of blue whale calls during a low/medium powered seismic survey which used a sparker as the seismic source;
- Bowles *et al.* (1994) documented a decrease in sperm whale and pilot whale vocalisations during controlled exposure to underwater noise; and
- IWC (2007) documented a decrease in sperm whale 'creaks' (associated with feeding behaviour) and that fin whales stopped calling (associated with breeding behaviour) during a seismic survey.

Changes in diving behaviour have also been associated with seismic surveys; for example gray whale dive durations increased during a seismic survey off Sakhalin Island (Gailey *et al.,* 2007); however, no associated change in dive frequency was noted (Yazvenko 2007). Robertson *et al.* (2013) found that bowhead whales spend significantly shorter periods of time at the surface between dives during seismic surveys.

Mitigation measures such as operational shut downs and careful timing of seismic surveys (to avoid high densities of animals during sensitive life history stages) can serve to significantly reduce the behavioural effects associated with seismic survey disturbance on marine mammals (Gailey *et al.,* 2016).

Schlumberger intends to reduce the behavioural effects on marine mammals during the Pegasus Basin Seismic Survey by:

- Compliance with the Code of Conduct which requires visual and acoustic detection of marine mammals by dedicated MMOs and PAM operators, suitable mitigation zones to address the behavioural threshold of 171 dB re 1 μPa^2-s and delayed starts and shut-downs to minimise the behavioural effects on marine mammals; and
- Conducting operations during summer/autumn months to reduce the likelihood of displacement on migrating blue and humpback whales in winter.

Based on the information above, some marine mammal behavioural effects are possible when marine mammals are in the vicinity of the Pegasus Basin Seismic Survey. These effects will be strictly temporary and will cease as soon as the survey ceases. It is considered that acoustic disturbance will confer a ***medium*** (possible x moderate) risk of behavioural effects to marine mammals during the Pegasus Basin Seismic Survey.

Seabirds

Feeding activities of seabirds could possibly be interrupted by seismic operations. Birds in the area could be alarmed as the operating seismic vessel passes close-by, causing them to stop diving and be displaced to other foraging areas (MacDuff-Duncan & Davies, 1995). The displacement of bait fish could also lead to a reduction in seabird diving activities and foraging potential.

Pelagic seabirds are protected from acoustic disturbance to some degree on the basis that their feeding and resting activities are largely restricted to surface waters where underwater noise is reduced by the 'Lloyd mirror effect' (Carey, 2009).

The risk of potential disruption to seabird behaviour by the Pegasus Basin Seismic Survey is considered to be ***low*** (possible x negligible) on account of the potential temporary disturbance to feeding activities.

Marine Turtles

While it is highly unlikely that any turtles will be encountered during the Pegasus Basin Seismic Survey, patterns of avoidance and behavioural responses have been observed in turtles. When captive sea turtles (a loggerhead and a green turtle) were exposed to an approaching acoustic source, they displayed patterns of avoidance and behavioural responses (McCauley *et al.*, 2000). An increase in swimming speed was observed at a received level of 166 dB re 1 μPa rms, while avoidance through erratic swimming was observed at a received level around 175 dB re 1 μPa rms (McCauley *et al.*, 2000). For a 3D seismic survey in 100 – 120 m water, these results suggest a behavioural change at 2 km and avoidance at 1 km from the active source.

In the unlikely event that a turtle is present in close proximity to the operating seismic vessel during the Pegasus Basin Seismic Survey, some behavioural changes may occur, however no specific mitigation measures are in place. Due to the unlikely occurrence of turtles in the Operational Area and the relatively short-term nature of the survey, it is considered that the risk of seismic operations to marine turtles will be ***low*** (unlikely x minor).

Fish, Cephalopods and Fisheries

Investigations into behavioural impacts from seismic surveys on fish are typically carried out either experimentally whereby caged fish are exposed to an acoustic source, or via studies that assess catch-effort data before and after a seismic survey. Interpretation of such experiments must be done with caution as variability in experimental design (e.g. source level, line spacing, timeframe, geographic area etc.) and the subjects (e.g. species, wild or farmed, demersal or pelagic, migrant or site-attached, age etc.) often make it difficult to draw overall conclusions and comparisons. In addition, captive studies typically only provide information on behavioural responses of fish during and immediately after the onset of the noise (Popper & Hastings, 2009). Such behavioural observations are also potentially biased by the fact that the subjects are constrained, reducing/removing their ability to exhibit large scale avoidance behaviours that would otherwise be possible in the wild.

In general, there is little indication of long-term behavioural disruptions of fish when exposed to seismic sources. Short-term responses are often observed such as startle responses (Pearson *et al.*, 1992; Wardle *et al.*, 2001; Hassel *et al.*, 2004; Boeger *et al.*, 2006), modification in schooling patterns and swimming speed (Pearson *et al.*, 1992; McCauley *et al.*, 2000; Mueller-Blenkle *et al.*, 2010; Fewtrell & McCauley, 2012), freezing (Sverdrup *et al.*, 1994), and changes in vertical distribution within the water column (Pearson *et al.*, 1992; Fewtrell & McCauley, 2012). Hassel *et al.* (2004) and Mueller-Blenkle *et al.* (2010) also found evidence of habituation through an observed decrease in the degree of startle response with time.

Seismic surveys often result in the vertical or horizontal displacement of fish away from the acoustic source; pelagic fish tend to dive deeper (McCauley *et al.*, 2000), while reef fish return to the reef for shelter as the acoustic source approaches, resuming normal activity once the disturbance has passed (Woodside, 2007; Colman *et al.*, 2008). Pearson *et al.* (1992) also observed vertical displacement of rockfish on exposure to air-gun sounds.

Any change to fish behaviour from a seismic survey can potentially also affect commercial fishing operations (McCauley *et al.,* 2000). Reductions in catch per unit effort for commercial fishing vessels operating close to seismic operations have been demonstrated (Skalski *et al.*, 1992; Engas *et al.*, 1996; Bendell, 2011; Handegard *et al.*, 2013), with effects lasting up to five days following the conclusion of seismic operations. However, there has been no evidence of long-term stock displacement and these results have been debated: with Gausland (2003) attributing this effect to natural fluctuations in fish stocks or long-term negative population trends that are unrelated to the seismic operations.

Over the last 40 years seismic surveys have become a common feature in the North Sea. Bendell (2011) considered long-line catches off the coast of Norway during the acquisition of a two week seismic survey with a peak source level of 238 dB re 1µPa@1m. Catch rates reduced by 55 – 80% within 5 km from the active source, although these reductions were temporary; catch rates returned to normal within 24 hours of seismic operations ceasing (Bendell, 2011).

Other studies have concluded that seismic surveys do not affect commercial fisheries. In Lyme Bay (UK), the distribution of bass was documented during a long-term seismic survey (three and a half months) operating at a peak source of 202 dB re 1µPa@1m. No long-term changes in distribution were observed, and tagged fish recaptures demonstrated that there were no large scale emigrations from the survey area (Pickett *et al.*, 1994). Similarly, a study of fish in the Adriatic Sea reported no observed changes in pelagic biomass following an acoustic disturbance with a peak of 210 dB re 1µPa@1m, indicating that catch rates were unlikely to be affected (Labella *et al.*, 1996). A case study on catch rates around the Faroe Islands also noted that although fishers perceived a decrease in catch during seismic operations, their logbook records during periods both with and without seismic operations revealed no statistically significant effect from acoustic disturbance (Jakupsstovu *et al.*, 2001).

Behavioural changes have also been documented for cephalopods (squid and octopus species) in response to acoustic disturbance. Caged cephalopods exposed to acoustic sources demonstrated a startle response to sources above 151 – 161 dB re 1 µPa and showed behavioural changes towards surface activity in order to avoid acoustic disturbance (McCauley *et al.*, 2000). McCauley *et al.* (2000) demonstrated that the use of soft-starts effectively decreases startle responses in cephalopods and Fewtrell & McCauley (2012) confirmed these findings and demonstrated that a source level of 147 dB re 1 µPa was necessary to induce an avoidance response in squid. Other squid reactions observed by Fewtrell & McCauley (2012) were alarm responses (inking and jetting away from the source), increased swimming speed, and aggressive behaviour. The authors noted that the reaction of squid decreased with repeated exposure, suggesting either habituation or hearing loss (Fewtrell & McCauley, 2012).

It is likely that pelagic fish and cephalopods will avoid the immediate vicinity of any acoustic disturbance during the Pegasus Basin Seismic Survey. These predicted distributional changes could in turn result in the short-term displacement of commercially valuable fish stocks from the acquisition area, leading to a potential increase in the effort required to locate viable stocks and maintain catch rates.

Acoustic disturbance to fish and cephalopods is therefore possible during the Pegasus Basin Seismic Survey and will be minimised through the following mitigation measures:

- The use of soft starts; and
- Operations will occur 24/7 (weather and marine mammal encounters permitting) to ensure the survey will progress as quickly as possible, minimising the duration of any effects.

Commercial fishers have been advised of the Pegasus Basin Seismic Survey and will be informed of the predicted start date and schedule closer to the time. With these mitigation measures in place it is considered that the risk of behavioural disruptions to fish and cephalopods and the consequences to fisheries during the Pegasus Basin Seismic Survey is ***medium*** (likely x minor)***.***

Crustaceans

Although there is limited information on behavioural responses of crustaceans to acoustic disturbances, the following is a summary of the available literature. Also included is a recent study which was undertaken by University of Tasmania's Institute for Marine and Antarctic Studies in conjunction with Curtin University's Centre for Marine Science and Technology to investigate the potential impact of seismic surveys on southeast Australian scallop and lobster fisheries (Day *et al*., 2016). This study looked at exposure levels to rock lobster using a commercial seismic source operating in 30-100 m of water depth passing withing 200-500 m range of the test animals.

Andriguetto-Filho *et al.* (2005) did not find any effects on catch rates of three species of shrimp (southern white shrimp, southern brown shrimp and Atlantic seabob) during a seismic survey with a peak source level of 196 dB re 1 µPa at 1 m. Similarly, Parry and Gason (2006) documented no effect on catch rates from a lobster fishery spanning 25 years during which 28 seismic surveys (2D and 3D) occurred. In this study, the number of seismic pulses was correlated to catch per unit effort data over 12 depth stratified regions in the Western Rock Lobster Zone (Western Victoria, Australia). The catch per unit effort data detected no significant change in catch rates during the weeks and years following seismic surveys, from which the authors concluded that there were no detectable impacts on rock lobster fisheries (Parry & Gason, 2006). Playback experiments of ship noise were found to disrupt foraging behaviour in shore crabs and also to reduce antipredator behaviours (Wale *et al.,* 2013).

The Day *et al*. (2016) study found that seismic exposure did not result in any lobster mortality over all the experiments; however some sub-lethal effects were observed such as reflexes and ability for lobster to control its positioning. The studies undertaken on hatched rock lobster larvae were found to be unaffected in terms of egg development, the number of hatch larvae, larval dry mass and engery content and larval competency. It was concluded that seismic surveys appear unlikely to result in immediate large scale mortality in the southern rock lobster fishery and on their own, do not appear to result in any degree of mortality (Day *et al*., 2016). In addition to this, early stage lobster embryos showed no effect from air gun exposure, indicating that at this point in the life history, they are resilient to exposure and subsequent recruitment should be unaffected.

Within New Zealand waters red rock lobster (commonly known as crayfish) is the most well-known and commonly harvested crustacean species in NZ and is important from a commercial, cultural and recreational perspective. They are found in coastal waters around NZ where rocky subtidal reefs are present. Commercial fishing for crayfish only extends out to the 12 Nm territorial sea and is concentrated on the eastern and southern coast of NZ (MPI, 2016g). As the Pegasus Basin Seismic Survey will be acquired outside of the territorial sea, it is considered that the effects on red rock lobster fisheries will be negligible.

Scampi and deep-water crabs (red crab, giant spider crab and two species of king crab) are also commercially harvested in NZ. Scampi are targeted by trawlers on grounds to the east of the North Island, the Chatham Rise, and the Auckland Islands, while the deep-water crabs are targeted by pots deployed in water depths up to 1,500 m (MPI, 2016f). As the Pegasus Basin Seismic Survey is far from the scampi fishing grounds and in water depths shallower than those fished for deep-water crab, the survey will not impact on these fisheries.

For the scallops studied in Day *et al*. (2016) there was no observation of any mass mortality of scallops in response to air gun exposure, and overall mortality rates among all experiments were at the low end of the range of the naturally occurring mortality rate. However, it was found that increases in the level of exposure to the acoustic source was found to significantly increase mortality. Scallop behaviour was observed to be altered by exposure to the acoustic source, with a decrease in classic behavious such as positioning, mantle irrigation and swimming. The scallops used in the Day et al. (2016) study were determined to be in a compromised physiological condition where it is likely they had reduced tolerance to subsequent stressors, including environmental, nutritional and pathological stressors.

Based on the information above, and the depth of the water within the Operational Area (> 400 m) the potential risk of acoustic disturbance to crustaceans and crustacean fisheries is considered to be ***low*** (unlikely x minor).

5.1.2.3 Potential perceptual effects on marine fauna

Marine Mammals

Marine mammals utilise sound to inform a range of behaviours such as foraging, navigation, communication, reproduction, parental care, and avoidance of predators, and to gain an overall awareness of the surrounding environment (Thomas *et al*., 1992; Johnson *et al*., 2009). The ability to perceive biologically important sounds is therefore crucial to marine mammals. Anthropogenic sounds produced in the same frequency as biological sounds could interfere with biologically important signals; an effect referred to as ‘masking’ (Richardson *et al.*, 1995; Di Iorio & Clark, 2009). The frequencies of marine mammal vocalisations (for communication and echolocation) relevant to the Operational Area are presented in **Table 28**.

Table 28 Cetacean Communication and Echolocation Frequencies

Species	Communication Frequency (kHz)	Echolocation Frequency (kHz)
Southern right whale	0.03 – 2.2	N/A
Minke whale	0.06 – 6	N/A
Sei whale	1.5 – 3.5	N/A
Bryde’s whales	nd	nd
Blue whale	0.0124 – 0.4	N/A
Fin whale	0.01 – 28	N/A
Humpback whale	0.025 – 10	N/A
Sperm whale	< 9	0.1 – 30
Pygmy sperm whale	nd	60 - 200
Beaked whales*	3 - 16	2 - 26
Hector’s dolphin	nd	129**
Common dolphin	0.5 - 18	0.2 - 150
Pilot whale	1 – 8	1 – 18
Dusky dolphin	nd	40 - 110***
Killer whale	0.1 – 25	12 – 25
Bottlenose dolphin	0.2 - 24	110 - 150

Source: Summarised from Simmonds *et al*., 2004

Key:
nd = no data available
* = using the bottlenose whale as an example
** = Kyhn *et al.,* 2009
*** = Au and Wursig, 2004

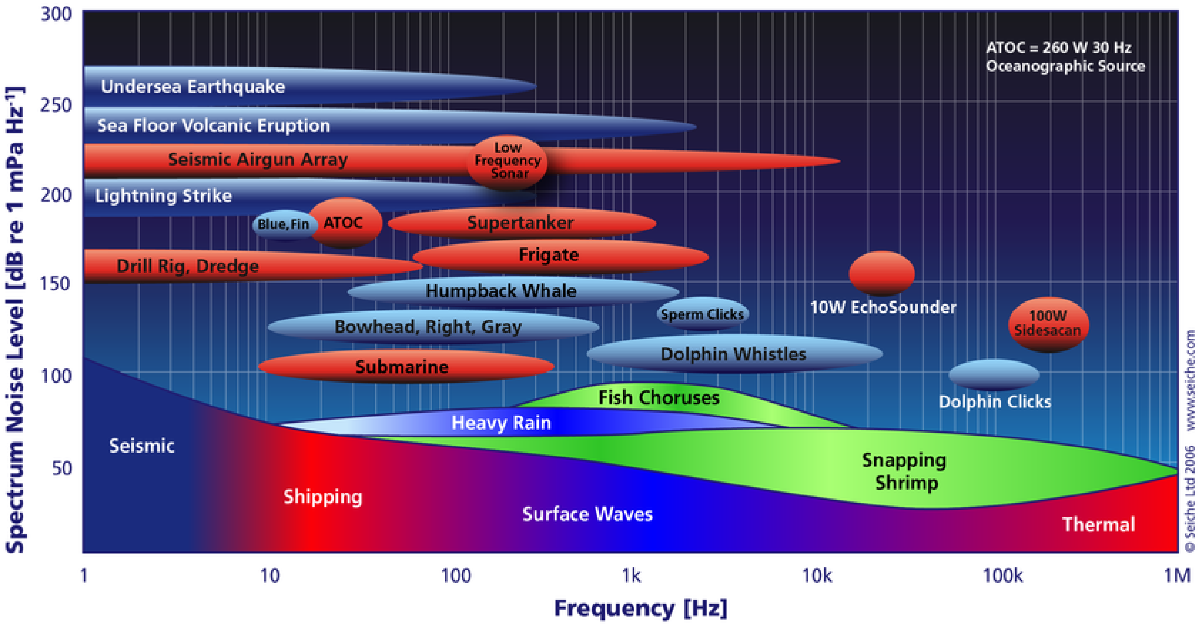
Cetaceans are broadly separated into three functional hearing groups (Southall *et al.*, 2007):

- Low frequency cetaceans have an auditory bandwidth of 0.007 kHz to 22 kHz. Species from this group which could occur in the Operational Area include southern right whale, minke whale, sei whale, humpback whale, blue whale, and fin whale;
- Mid-frequency cetaceans have an auditory bandwidth of 0.15 kHz to 160 kHz. Species from this group which could occur in the Operational Area include bottlenose dolphin, common dolphin, dusky dolphin, Risso's dolphin, false killer whale, killer whale, long-finned pilot whale, sperm whale, and beaked whales; and
- High frequency cetaceans have an auditory bandwidth of 0.2 kHz to 180 kHz. Species from this group which could occur in the Operational Area include the Hector's and Maui's dolphin, and pygmy sperm whales.

The sound frequencies emitted by seismic acoustic sources are broadband, with the majority of energy concentrated between 0.1 kHz and 0.25 kHz. Therefore, the greatest potential for a seismic source to interfere with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum. This means that the lowest frequency cetaceans (i.e. southern right, minke, sei, humpback, blue and fin whales) are likely to be most affected by 'masking' as the seismic acoustic source has the greatest potential to overlap with these low frequency vocalisations (**Figure 31**). Vocalisations of mid and high frequency cetaceans are less likely to be masked; however, shipping noise in coastal areas often has a higher frequency component that has in some circumstances been found to overlap with odontocete communication and echolocation (e.g. Veirs *et al*., 2016).

Adaptive responses to anthropogenic underwater noises have also been documented, such as changes in vocalisation strength, frequency, duration and timing (McCauley *et al*., 1998; Lesage *et al*., 1999; McCauley *et al*., 2003; Foote *et al.,* 2004; Nowacek *et al*., 2007; Di Iorio & Clark, 2009; Parks *et al.*, 2011; McGregor *et al.,* 2013). For example, the calls emitted by blue whales during social encounters and feeding increased when a seismic survey was operational nearby (Di Iorio & Clark, 2009); and a decrease in fin whale song spectral frequencies was observed during a seismic survey in the Mediterranean Sea (Castellote *et al*., 2012). Such adaptations are thought to increase the probability that communication calls will be successfully received by reducing the effects of masking (McGregor *et al.,* 2013; Brakes and Dall, 2016). The calling rates of bowhead whales however, were found to vary with changes in received SELs from seismic surveys (Blackwell *et al.,* 2015). In this study, at very low SELs (only just detectable) calling rates increased. As SELs continued to increase, calling rates levelled off (as SELs reached 94 dB re 1μPa^2-s), then began decreasing (at SELs greater than 127 dB re 1μPa^2-s), with whales falling virtually silent once SELs exceeded 160 dB re 1μPa^2-s. Hence adaptations to masking for some species may be limited to circumstances when whales are subject to only moderate SELs.

Figure 31 Overlap of Ambient and Localised Noise Sources in the Ocean



(Source: Professor Rodney Coates, The Advanced SONAR Course, Seiche (2002); from www.seiche.com)

Masking of baleen whale calls in particular is possible for all seismic surveys. Hence, the risk of auditory masking of marine mammal vocalisations by the Pegasus Basin Seismic Survey is considered to be ***medium*** (possible x minor).

Fish

Some fish species use sound for communication, especially when alarming conspecifics of danger or during reproductive activities (DOSITS, 2016). Anthropogenic noise may interfere with such communication, for instance boat noise was found to mask acoustic communications in three vocalising fish species from the Adriatic Sea (Codarin *et al.,* 2009). Simpson *et al*. (2016) found that rates of predation were affected by ship noise, with twice as many fish prey being consumed whilst ship noise prevailed. This suggests that at least in some instances prey species may be at a disadvantage with regards to evading capture in noisy environments.

Little is known about the vocalisations of New Zealand fish, but globally, approximately 800 species from over 100 families are known to produce sound (Ladich & Fine, 2006); hence it is reasonable to expect that sound has an important function for at least some New Zealand species. It is therefore assumed that there is a ***medium*** (possible x minor) risk of auditory masking for fish during the Pegasus Basin Seismic Survey.

5.1.2.4 Potential physiological effects on marine fauna

Marine mammals

If a marine mammal is exposed to a high intensity underwater noise at close range, it can suffer physiological effects such as trauma or auditory damage (DOC, 2013). The sound intensities that would elicit such a result are largely unknown, with the current knowledge of traumatic thresholds based on only a few experimental species (Richardson *et al*., 1995; Gordon *et al*., 2003).

The main type of auditory damage documented in marine mammals is a 'threshold shift'. Threshold shifts essentially refer to hearing loss: when the exposed animal exhibits an elevation in the lower limit of their auditory sensitivity. These shifts can be permanent or temporary; temporary threshold shifts are more common in marine mammals due to their mobile, free-ranging nature which allows them to avoid areas in which SELs would be dangerously high. It is believed that to cause immediate serious permanent physiological damage in marine mammals, SELs would need to be very high (Richardson *et al*., 1995), and although different SELs affect mammal species differently, permanent threshold shifts are thought to occur between 218 – 230 dB re 1 μPa^2-s (Southall *et al*., 2007).

The Code of Conduct sets thresholds that predict the physiological effects on marine mammals in NZ waters during seismic surveys based on those presented in Southall *et al.* (2007). The physiological threshold (or 'injury criteria') is exceeded if marine mammals are subject to SELs greater than 186 dB re 1 μPa^2-s (DOC, 2013) which corresponds to the SEL at which temporary threshold shifts may start to occur. The Code of Conduct requires that seismic operators employ mitigation measures specifically designed to minimise the potential for marine mammals to be subject to SELs that have the potential to cause threshold shifts (both permanent and temporary). Compliance with the Code of Conduct's mitigation measures and stipulated thresholds is the fundamental way in which Schlumberger intends to minimise the potential of physiological damage to marine mammals during the Pegasus Basin Seismic Survey.

STLM results for the Pegasus Basin Seismic Survey indicate that the SELs are below the thresholds for both injury and behaviour at the stipulated mitigation zones. Schlumberger will conduct ground-truthing during the survey to verify the results of the STLM. In order to do this, representative data recorded on the seismic streamers during the seismic survey will be used to compare actual sound exposure levels with STLM predictions.

Temporary or permanent threshold shifts are unlikely due to the typical avoidance behaviours exhibited by marine mammals (see **Section 5.1.2.2**) and compliance with the Code of Conduct (i.e. pre-start observations, soft start and shut-down procedures) which serve to minimise the risk to marine mammals to as low as reasonably practicable.

On this basis it is considered that the acoustic effects could put marine mammals at ***medium*** (unlikely x major) risk of physiological effects.

In addition, if any stranding occurs that results in mortality during or shortly after seismic operations, Schlumberger will, on a case-by-case basis, consider covering the cost of a necropsy in an attempt to determine the cause of death. Schlumberger understands that DOC will be responsible for all logistical aspects associated with the necropsy, including coordination with pathologists at Massey University to undertake the work.

Seabirds

While physiological damage to seabirds could arise if one was to dive in very close proximity to an active acoustic source, it is more likely that birds in the path of the oncoming seismic vessel will move away from the area well before any physiological damage could occur. Seabirds resting on the sea surface are likely to be startled at the approach of the seismic vessel but are unlikely to experience any physiological effects (MacDuff-Duncan & Davies, 1995). On account of this, it is considered that the risk of physiological effects to seabirds form the acoustic source is ***low*** (unlikely x minor).

Fish

Sound can affect fish physiology in a number of ways depending on the source level and species affected. Such effects include an increase in stress levels (Santulli *et al*., 1999; Smith, 2004; Buscaino *et al*., 2010; Debusschere *et al*., 2016; Simpson *et al*., 2016), temporary or permanent threshold shifts (Smith, 2004; Popper *et al*., 2005), or damage to the animal's sensory organs (McCauley *et al*., 2003).

Scholik and Yan (2002) reported that a hearing threshold shift in fathead minnows was directly correlated to the sound frequency and the duration of exposure. A temporary threshold shift was observed after one hour of exposure to white noise at >1 kHz, but no threshold shift occurred at 0.8 kHz. Popper *et al.* (2005) observed varying degrees of threshold shifts in northern pike, broad whitefish, and lake-chub when exposed to a 730 in³ acoustic source, and although the degree of threshold shift varied, all species recovered within 24 hours of exposure. The Pegasus Basin Seismic Survey will use a 5,085 in³ acoustic source with a frequency between 2 and 250 Hz. Emissions will occur every 8-9 seconds during acquisition.

It is important to consider the species involved. For example, in the Popper *et al.* (2005) study, two species experienced a temporary threshold shift, while the third showed no evidence of an impact. There is no threshold shift data available for fish species specific to the Operational Area.

Pelagic fish will typically move away from a loud acoustic source (see **Section 5.1.2.2**), minimising their exposure to the sound and the potential for any hearing damage. As a result, the above data can be interpreted as a 'worst case scenario' for the few fish that remain in close proximity to the seismic source.

Woodside (2007) conducted a comprehensive investigation to assess the effects of a seismic survey on reef fish in Western Australia. Water depths within the study area ranged from 20 – 1,100 m and the seismic source had a total capacity of 2,005 in³. The study assessed a number of parameters including fish diversity and abundance, coral health, and any pathological changes to auditory tissues. Sound loggers and remote underwater video was deployed and fish exposure cages were utilised to contain captive reef fish. No temporary or permanent threshold shifts were documented for any species during this study.

During the Pegasus Basin Seismic Survey there is potential for the acoustic source to induce temporary physiological effects on fish species that are in close proximity to the acoustic source; however, the risk of any lasting physiological effects are considered to be ***low*** (unlikely x minor) as most pelagic fish are predicted to move away from and avoid the greatest SELs.

Cephalopods

Acoustic trauma has been observed in captive cephalopods. Andre *et al.* (2011) exposed four cephalopod species to low frequency sounds with SEL of 157 ± 5 dB re 1 μPa (peak levels at 175 re 1 μPa). All of the study animals exhibited changes to the sensory hair cells that are responsible for balance. Andre *et al.* (2011) estimated that such trauma effects could occur out to 1.5 – 2 km from the operating acoustic source.

Squid are found over the continental shelf in waters up to 500 m deep, but are most prevalent in water depths less than 300 m (MPI, 2014). Given this pelagic lifestyle, there is the potential for squid to come into close proximity to the acoustic source during the Pegasus Basin Seismic Survey. Squid can readily move away from the highest SELs, therefore the duration of exposure during the survey is expected to be low. In addition, squid species are generally short-lived, fasting growing, and have high fecundity rates (MFish, 2014); these life history traits indicate that they are well adapted to disturbances. As a result, there are no anticipated long-term risks to squid populations.

Octopus species inhabit both coastal and offshore waters; some species inhabit reefs, while others can be found over soft sediment. Those species that prefer reef habitat tend to be primarily coastal species (e.g. *Octopus maorum*) and are likely to have higher site fidelity than open water species which are more likely to move away from disturbance. The offshore nature of the Pegasus Basin Seismic Survey will reduce the exposure of coastal reef dwelling species to underwater noise.

Based on the information above, the risk of physiological trauma to cephalopods is considered to be ***low*** (occasional x negligible).

Crustaceans and Molluscs

Research has shown that some species of crustaceans and molluscs (scallop, sea urchin, mussels, periwinkles, crustaceans, shrimp, gastropods) suffer very little mortality below sound levels of 220 dB re 1μPa@1m, while some show no mortality at 230 dB re 1μPa@1m (Royal Society of Canada, 2004). Based on the STLM results for the Pegasus Basin Seismic Survey, sound levels of this intensity would only be reached in very close proximity to the acoustic source (i.e. within approx. 10 m).

Moriyasu *et al.* (2004) compiled a literature review on the effects of noise on crustaceans and molluscs. One reviewed study used a single acoustic source with source levels of 220 – 240 dB re 1 μPa on mussels and amphipods at distances of 0.5 m or greater. The results showed no detectable effects. Another study from the Wadden Sea exposed brown shrimp to a source level of 190 dB re 1 μPa@1m, in water depths of 2 m. This study found no mortality or evidence of reduced catch rates. It has been suggested that the lack of a swim bladder in these species reduces the likelihood of physiological damage.

Playback experiments of ship noise on shore crabs led to an initial increase in oxygen consumption which was interpreted to perhaps represent an indication of stress. Repeated exposure elicited no cumulative response indicating that some form of habituation or tolerance was occurring (Wale *et al*., 2013a).

Based on these results above and the details provided within **Section 5.1.2.2**, and the fact that the shallowest water depth throughout the Operational Area is approximately 400 m, it is considered that the risk of physiological effects to crustaceans and molluscs will be ***low*** (likely x negligible).

Deep-water Benthic Communities

The potential effects of sound on deep-water benthic communities are not well understood and there is a notable lack of literature on the topic. Potential effects on threatened species such as deep-water corals are of primary concern.

With regard to the effects of seismic operations on coral, it has been hypothesised that high SELs could eject or damage polyps on the calcium carbonate skeleton of corals. However, Woodside (2007) detected no lethal or sub-lethal effects of a seismic survey on warm water corals in shallow water. This study was the first to provide empirical evidence to suggest that seismic surveys can be undertaken in sensitive coral reef environments without significant adverse impacts (Colman *et al.,* 2008).

In New Zealand, deep-water corals (e.g. black coral and stylasteroid hydrocorals) are generally found at depths greater than 200 m (see **Section 4.2.2.1**). Mortality of coral larvae is known to occur within 5 m of an acoustic source (DIR, 2007). However, black coral are protected from such close contact as their larvae are negatively buoyant and do not disperse very far from their parent colony (Parker *et al*., 1997; Consalvey *et al*., 2006).

The information above, suggests that deep-water coral communities are unlikely to be significantly affected by the Pegasus Basin Seismic Survey. It is therefore predicted that noise from the Pegasus Basin Seismic Survey will pose a ***low*** (unlikely x negligible) risk to deep-water corals.

Planktonic Larvae

The larvae of fish and invertebrates generally have a pelagic planktonic stage during early development. When in close proximity to an operating acoustic source, plankton are vulnerable to physiological damage. A number of studies have indicated that mortality of planktonic communities can occur if they are within 5 m of an active acoustic source (Payne, 2004; DIR, 2007).

There is limited literature on the effects of seismic surveys on the larvae of NZ species; however, Aguilar de Soto *et al.* (2013) has examined how seismic pulses affect the larvae of NZ scallops. In order to assess the effect of noise on early larvae development, scallop larvae were exposed to seismic pulses of 160 dB re 1 µPa@1m in 3 second intervals within one hour after fertilisation. The effects of noise exposure at 24 to 90 hours of development were investigated and compared to a control group (that experienced no anthropogenic noise). Of the experimental larvae, 46% showed abnormalities in the form of malformations, such as localised bulges in soft tissues. No malformations were observed within the control groups. This study provided the first evidence that continual sound exposure causes growth abnormalities in larvae and it is assumed that other larval shellfish and fish may be prone to similar impacts.

Despite indicating larval vulnerability, it is important to put the results of the Aguilar de Soto *et al.* (2013) study into context. The experimental study was restricted to newly fertilised larvae that were exposed to high intensity sounds every 3 seconds for an extended duration (24 – 90 hours). In contrast, the Pegasus Basin Seismic Survey will emit an acoustic pulse every 8 seconds and exposure time will be much shorter since the source is constantly moving at ~4.5 kts and will pass most acquisition lines only once. Furthermore, this study used pulse duration of 1.5 seconds whereas the pulse duration for a seismic array is typically around 30 milliseconds. Mass spawning is typical of many fish and invertebrates, with large numbers of larvae produced to sustain the inherently high mortality associated with broadcast spawning in the marine environment.

The effect of seismic surveys on larval settlement rates is of commercial interest. Knowledge of the timing of larval settlement can help with predicting potential effects. For example, the primary settlement phase for NZ rock lobsters is late winter/spring (Forman *et al*., 2014); hence little temporal overlap is predicted between settlement and seismic operations.

Based on the information above it is considered that the population level risk to planktonic larvae is ***low*** (likely x negligible).

5.1.3 Waste discharges/emissions

During the Pegasus Basin Seismic Survey, the survey vessels will produce the following forms of waste:

- Biodegradable waste (sewage, grey water, galley waste and oily water);
- Non-biodegradable waste (garbage); and
- Exhaust emissions.

Inappropriate discharges of these wastes have the potential to cause adverse effects on the environment. The volume of waste generated is dependent on the number of crew on-board the vessels and the duration of the survey. All wastes produced will be managed in accordance with Schlumberger's standard environmental practices and MARPOL requirements (as enacted by the Marine Protection Rules for operations in the EEZ).

5.1.3.1 Potential effects from biodegradable waste

The primary forms of biodegradable waste produced during the Pegasus Basin Seismic Survey will be sewage, greywater, galley waste and oily water. When discharged to the marine environment, such wastes are decomposed by bacteria either in the water column or on the seabed. This decomposition process increases the biochemical oxygen demand in the surrounding area, which can potentially limit the amount of dissolved oxygen available to other marine organisms. This is particularly so in low flow areas where water circulates slowly. Biodegradable wastes can also lead to areas of artificial enrichment of phosphorous and nitrogen which, in extreme cases, can trigger excessive algal growth.

The survey vessels involved in the Pegasus Basin Seismic Survey contain on-board sewage treatment plants that ensure a high level of treatment before any sewage or grey-water is discharged. Where applicable, vessels involved in the survey will also be required to hold an International Sewage Pollution Prevention Certificate.

Only galley waste in the form of biodegradable food scraps will be discharged at sea during the survey. This discharge will occur in accordance with the NZ Marine Protection Rules, whereby food scraps will only be discharged to sea at distances greater than 12 Nm from land, or only comminuted wastes (<25 mm) will be discharged between 3 and 12 Nm.

Oily waters are generally derived from the bilges; the survey vessels will have a bilge water treatment plant that ensures any discharge is below the required 15 ppm.

MARPOL Annex V requirements will be followed for all aspects of waste disposal. In particular, records will be kept detailing type, quantity, and disposal route, with the records made available for inspection on request.

The risk from routine discharges of biodegradable waste during the Pegasus Basin Seismic Survey is considered to be ***low*** (likely x negligible).

5.1.3.2 Potential effects from non-biodegradable waste

Discharges of solid non-biodegradable wastes to the marine environment can have severe detrimental effects on marine fauna. Such effects include entanglement, injury, and ingestion of foreign objects. All non-biodegradable wastes produced during the Pegasus Basin Seismic Survey will be returned to shore and disposed of in adherence to local waste management requirements, with all chain of custody records retained.

The environmental risk from discharges of non-biodegradable wastes to the marine environment is considered to be ***low*** (rare x negligible).

5.1.3.3 Potential effects from atmospheric emissions

The principle source of atmospheric emissions during the Pegasus Basin Seismic Survey is combusted exhaust gasses. Most of these emissions will be in the form of carbon dioxide, although smaller quantities of other gasses such as oxides of nitrogen, carbon monoxide, and sulphur dioxide may be emitted. These types of emissions are classed as greenhouse gas emissions and are linked to climate change. Combusted exhaust gasses can also reduce ambient air quality, leading to human health issues in populated areas.

The survey vessels will hold International Air Pollution Prevention Certificates, which ensure that all engines and equipment are regularly serviced and maintained to minimise emissions. Low sulphur fuel is also common place on seismic vessels, which also serves to reduce atmospheric emissions.

Given the offshore nature of the survey and the proactive management of emissions, the environmental risk is considered to be ***low*** (likely x negligible).

5.1.4 Cumulative Effects

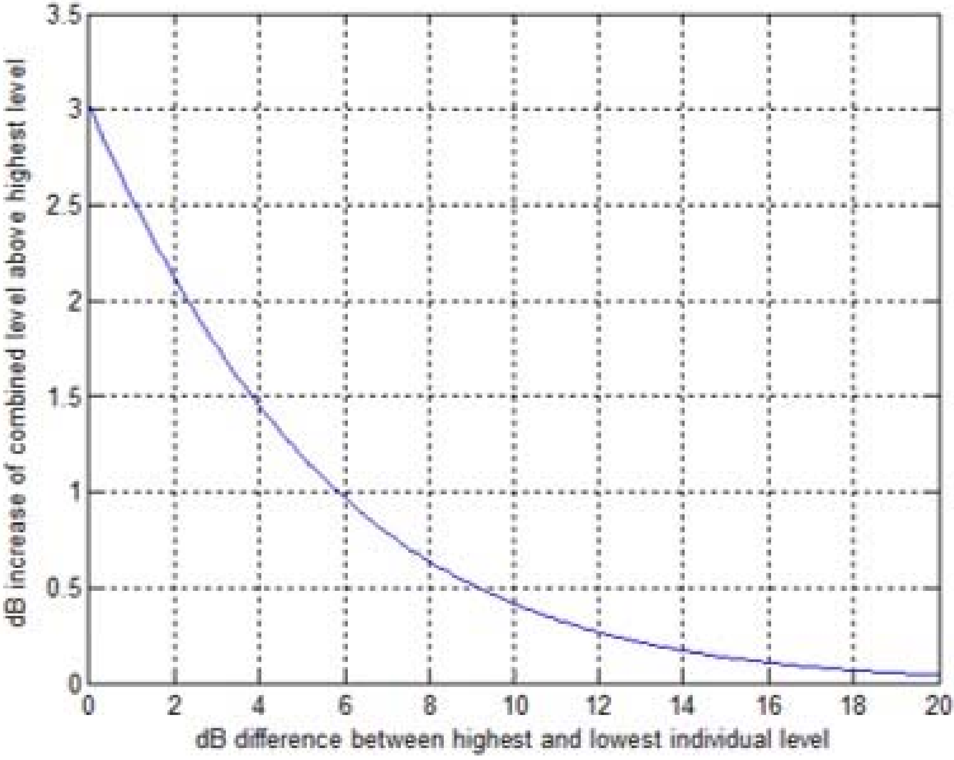
'Cumulative effects' refers to the interaction of the potential effects from the Pegasus Basin Seismic Survey with environmental effects that arise from other marine activities (e.g. other seismic surveys, marine traffic, fishing operations, etc.). The primary concern for seismic surveys is the potential for cumulative acoustic effects that could result when multiple sources of underwater noise combine to significantly increase the underwater sound profile. In particular, cumulative effects associated with other seismic surveys and shipping traffic are discussed below.

Assessing cumulative effects in a quantitative manner is fraught with difficulties and as a result few studies have broached this topic in relation to seismic surveys. Di Iorio and Clark (2009) assessed the calling rate of blue whales during a seismic survey. They concluded that shipping noise in the operational area did not account for any of the observed changes in the acoustic behaviour of blue whales, and that the seismic survey was solely responsible for the observed changes. Such results are relevant in an environment where heavy levels of shipping existed prior to any seismic operations, but in areas where shipping levels are historically lower, the combinations of a seismic survey with shipping noise could result in greater disturbance to marine mammals than from either activity in isolation. In such circumstances, it is probable that some masking of marine mammal vocalisations, especially the low frequency calls of baleen whales, could occur. The zone of impact of masking effects could be relatively large given the low frequency nature of shipping and seismic noises which propagate over long distances.

Recent studies have provided evidence to suggest that in the presence of consistent noise, marine mammals will adapt their vocalisations, presumably to mitigate against the effects of masking (e.g. McGregor *et al*., 2013) (also see **Section 5.1.2.3**). These studies support the notion that the most significant masking effects can be expected in areas where baseline noise levels are typically low.

When the acoustic outputs from two difference seismic surveys combine, the outcome is counter-intuitive; the largest difference between the combined and individual SELs will be 3 dB re 1μP^{2-}s, however this will only occur when both surveys produce an identical SEL. To put this into context, if at a given location Survey 'A' by itself would produce a SEL of 160 dB re 1μP^{2-}s, and Survey 'B' by itself would also produce an SEL of 160 dB re 1μP^{2-}s, then the two surveys combined will produce an SEL of 163 dB re 1μP^{2-}s (Alec Duncan pers. comm.). However, if one survey produced a higher SEL, then the higher SEL would dominate to the point where if Survey 'A' produces an SEL of 6 dB re 1μP^{2-}s higher than Survey 'B', then the combined level is 1 dB re 1μP^{2-}s higher than the higher of the individual SELs (i.e. Survey A) (**Figure 32**).

Figure 32 Combined Sound Exposure from Two Seismic Sources



Cumulative effects are much more likely to occur when two surveys are operating close together in both time and space. It is hypothesised that a cetacean may be able to reorient and cope with a single sound source emitted from a seismic survey, but may be less able to cope with multiple sources.

The potential for cumulative effects from interactions with other seismic operations is also likely to be related to physical features such as depth, bathymetry and coastline shape. A higher risk is present in shallow waters and enclosed bays or areas, where the attenuation potential is lower. Resident populations (such as Hector's or Maui's dolphins) will be more sensitive to cumulative effects than will migratory or non-resident populations (for example humpback whales).

Schlumberger are not currently unaware of another seismic survey on the east coast of New Zealand that could potentially occur concurrently with the Pegasus Basin Seismic Survey. However, if this was to occur, Schlumberger would reassess the potential for cumulative impact should they become aware of additional concurrent seismic operations as the planning for this survey progresses.

The low frequency nature of shipping noise is not unlike that of seismic, in that it travels long distances underwater. Offshore east coast North Island is frequently used by large ships in transit between North and South Island destinations. Hence background shipping noise is likely to be a constant in the Operational Area and both alone and in conjunction with the Pegasus Basin Seismic Survey could contribute to masking effects of marine mammal vocalisations.

Despite the potential for some masking to occur, no specific additional mitigation measures are recommended to address cumulative effects, as the management of acoustic effects of seismic surveys is already managed to 'as low as reasonably practicable' through the Code of Conduct requirements. Without information about the SELs from all other noise sources in and around the Operational Area it is not possible to ascribe a level of risk to potential cumulative effects.

5.2 Unplanned Event – Potential Effects and Mitigations

The unplanned events associated with seismic operations include the introduction of invasive marine species, streamer loss, hydrocarbons spills, or a vessel collision/sinking. Although such unplanned events are rare during seismic operations, the potential effects of such incidents must be given serious consideration as the consequences can be high. Each potential unplanned event is discussed below.

5.2.1 Potential effects of invasive marine species

The introduction of and spread of marine pests or invasive species to NZ waters can occur through ballast water discharges, sea chests and hull fouling on vessels.

As part of the environmental management commitments for the proposed Pegasus Basin Seismic Survey, Schlumberger have committed to mitigate the risk of introducing invasive marine species by requiring that the survey and support vessels are inspected by qualified invasive marine species inspectors prior to the vessels entering the country. Based on the outcomes of the inspections, management measures will be implemented to ensure the vessels meet the Part 2.1 'Clean Hull Requirement' of the Craft Risk Management Standard – Biofouling on Vessels Arriving to NZ. All survey vessels brought into the country will also adhere to the 'Import Standard for Ballast Water Exchange'. On this basis, the potential risk of introducing invasive marine species during the survey is therefore considered to be ***low*** (rare x minor).

5.2.2 Potential effects from streamer loss

Potential damage or loss of streamers could occur in the event that they become snagged on floating debris, rupture from abrasions or shark bites, or are severed (e.g. if another vessel accidentally crossed the streamer). As solid streamers are negatively buoyant they would sink if severed; therefore, if a streamer is lost there is potential for the severed portion to make contact with the seabed.

Solid streamers fitted with self-recovery devices will be used during the Pegasus Basin Seismic Survey. The self-recovery devices are programmed to activate at a depth of approximately 50 m, bringing the severed streamer back to the surface for retrieval. The use of self-recovery devices will minimise the potential for damage to the seabed and benthic communities in the event of streamer loss.

The Pegasus Basin Seismic Survey will also be undertaken by experienced personnel, therefore the environmental risk from streamer loss is considered to be ***low*** (possible x negligible).

5.2.3 Potential effects from hydrocarbon spills

A hydrocarbon spill has the potential to arise from a number of causes; a refuelling incident at sea, product leakage from storage or equipment, or hull/fuel tank failure due to a collision or sinking.

A refuelling incident at sea is the most likely to cause of a hydrocarbon spill into the marine environment during the Pegasus Basin Seismic Survey. Refuelling of the seismic vessel will be undertaken at sea approximately every five weeks from the support vessel. Potential causes of a fuel spill during refuelling include hose rupture, coupling failures or tank overflow. The *M/V Amazon Warrior* has a detailed refuelling protocol and procedures are in place to prevent any incidents. Spills caused by fuel handling mishaps are rare due to well-tested monitoring and management systems.

If a spill from the fuel tank of the seismic vessel did occur, the maximum possible volume spilt would be 3,941 t. For this to occur there would have to be a complete failure of the vessel's fuel containment systems, or a catastrophic failure of hull integrity. The high-tech navigational systems on-board, adherence of the COLREGS and operational procedures aligned with international best practice will ensure that such risks are minimised.

Where applicable, all vessels involved in survey operations will have an approved and certified Shipboard Oil Pollution Emergency Plan and an International Oil Pollution Prevention Certificate, as per MARPOL 73/78 and Marine Protection Rules Part 130A and 123A.

During refuelling operations, the following mitigation actions will be adhered to in order to prevent a hydrocarbon spill:

- Refuelling will only be undertaken during daylight and when sea conditions are appropriate as determined by the vessel master;
- A job hazard analysis (or equivalent) will be in place and reviewed before each fuel transfer;
- Transfer hoses will be fitted with 'dry-break' couplings (or similar and checked for integrity);
- Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas;
- Refuelling operations will be manned to ensure constant visual monitoring of gauges, hoses, fittings and the sea surface; and
- Radio communications will be maintained between the seismic vessel and support vessel.

In the event that a spill occurs during refuelling, a spill response will initially be undertaken in accordance with the Shipboard Oil Pollution Emergency Plan, and notification will be provided to Maritime NZ as required.

Based on the information presented above and the mitigation actions in place, it is considered that the risk of effects from a hydrocarbon spill is ***low*** (unlikely x minor).

5.2.4 Potential effects from vessel collision or sinking

If a collision occurred during the seismic operations, the biggest threats to the environment would be the vessel reaching the sea floor and/or the release of any hazardous substances or hydrocarbons. An incident of this nature is extremely unlikely and risks are mitigated through the constant presence of a support vessel and adherence to the COLREGS. As a result, the risk of a vessel collision or sinking incident is considered to be ***low*** (rare x moderate).

5.3 Environmental Risk Assessment Summary

A summary of the ERA results is presented in **Table 29**.

Table 29 Summary of ERA Results for the Pegasus Basin Seismic Survey

Effects from Planned Activities	**Consequence**	**Likelihood**	**Risk Ranking**
Physical presence of seismic vessel and towed equipment – marine mammal effects	Minor	Likely	Medium
Physical presence of seismic vessel and towed equipment – seabird effects	Negligible	Likely	Low
Physical presence of seismic vessel and towed equipment – fisheries/marine traffic effects	Minor	Likely	Medium
Physical presence of seismic vessel and towed equipment – marine archaeology effects	Negligible	Unlikely	Low
Acoustic disturbance – behavioural effects on marine mammals	Moderate	Possible	Medium
Acoustic disturbance – behavioural effects on seabirds	Negligible	Possible	Low
Acoustic disturbance – behavioural effects on turtles	Minor	Unlikely	Low
Acoustic disturbance – behavioural effects on fish and cephalopods & impacts on fisheries	Minor	Likely	Medium
Acoustic disturbance – behavioural effects on crustaceans	Minor	Unlikely	Low
Acoustic disturbance – perceptual effects on marine mammals	Minor	Possible	Medium
Acoustic disturbance – perceptual effects on fish	Minor	Possible	Medium
Acoustic disturbance – physiological effects on marine mammals	Major	Unlikely	Medium
Acoustic disturbance – physiological effects on seabirds	Minor	Unlikely	Low
Acoustic disturbance – physiological effects on fish	Minor	Unlikely	Low
Acoustic disturbance – physiological effects on cephalopods	Negligible	Occasional	Low
Acoustic disturbance – physiological effects on crustaceans and molluscs	Negligible	Likely	Low
Acoustic disturbance – physiological effects on deep water benthic communities	Negligible	Unlikely	Low
Acoustic disturbance – physiological effects on planktonic larvae	Negligible	Likely	Low
Effects from the discharge of biodegradable waste	Negligible	Likely	Low
Effects from the discharge of galley non-biodegradable waste	Negligible	Rare	Low
Effects from atmospheric emissions	Negligible	Likely	Low
Effects from Unplanned Events	**Consequence**	**Likelihood**	**Risk Ranking**
Effects from invasive marine species	Minor	Rare	Low
Effects from streamer loss	Negligible	Possible	Low
Effects from hydrocarbon spills	Minor	Unlikely	Low
Effects from vessel collision or sinking	Moderate	Rare	Low

6 ENVIRONMENTAL MANAGEMENT PLAN

The management of environmental risks is fundamental to Schlumberger's operating philosophy. The protocols outlined in the MMMP (**Appendix E**) are the primary measures by which Schlumberger proposes to manage environmental risks during the Pegasus Basin Seismic Survey. The MMMP is the operating procedure that is followed by MMOs and the seismic vessel crew while at sea in order to ensure compliance with the Code of Conduct.

Some additional measures over and above the requirements of the Code of Conduct will also be in place during the Pegasus Basin Seismic Survey. As well as being reflected in the MMMP, these measures are summarised in the Environmental Management Plan (EMP) presented in **Table 30**.

The EMP is essential for the successful implementation of the Pegasus Basin Seismic Survey. It summarises the key environmental objectives, the full suite of mitigation measures, and the regulatory and reporting requirements and commitments outlined in this MMIA.

Table 30 Pegasus Basin Seismic Survey Environmental Management Plan

Environmental Objectives	Proposed Controls	Relevant Legislation or Procedure
Minimise behavioural and physiological effects to marine fauna	• Continuous Line Acquisition and around the clock operations will reduce the temporal scale of impacts to ~6 months • The slow speed (4-5 knots) of the seismic vessel will reduce the potential for collisions with marine fauna • The survey timing is not predicted to significantly affect whale migration behaviours • All seismic operations outside 12 nm, hence effects on coastal species & larvae will be minimised ➢ Visual and acoustic detections of marine mammals to prompt required delayed starts and shut-downs ➢ Soft starts to ensure that mobile fauna can avoid the highest SELs ➢ Adherence to an approved Marine Mammal Mitigation Plan ➢ STLM has been conducted to assess the appropriateness of standard mitigation measures in the Code of Conduct ➢ PAM equipment has been approved as suitable for high frequency NZ Species of Concern (**Appendix F**) • An iwi observer will be present on the seismic vessel which will effectively increase the watch-keeping capacity for marine mammals • Marine mammal sightings will be collected whilst in transit to the Operational Area • MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea • MMOs to notify DOC immediately of any Hector's/Maui's dolphin sightings • Weekly MMO reports to be provided to DOC and EPA • Schlumberger will consider covering the cost of necropsies on a case-by-case basis in the event of strandings	Code of Conduct EEZ Act 2012 MMMP
Minimise disruption to fisheries and other marine traffic	• Continuous Line Acquisition and around the clock operations will reduce the temporal scale of impacts to ~6 months • Comply with the COLREGS and have a support vessel present at all times • Notify commercial fishers of the proposed survey and provide web-based real-time position information and scheduling • Issue a Notice to Mariners and a coastal navigation warning • Display a tail buoy at the end of each streamer to mark the overall extent of the towed equipment • All seismic operations outside 12 nm, hence effects on recreational fish stocks species will be minimised	COLREGS International best practice
Minimise effects on marine archaeology, cultural heritage, submarine infrastructure	• No planned activity will impact the seabed • All seismic operations are p;anned for outside 12 nm, where most sites of cultural significance are located	RMA 1991
Minimise potential of invasive species	• Survey vessels to be inspected by qualified invasive marine species inspectors • Adherence to Craft Risk Management Standard for Vessel Biofouling (CRMS) • Adherence to Import Health Standard for Ships Ballast Water (IHS)	Biosecurity Act 1993 IHS CRMS
Minimise effects on water quality	• All discharges to sea will occur in accordance with MARPOL and relevant NZ legislation • On-board sewage treatment plant and approved ISPPC as applicable • On-board bilge water treatment plant to ensure oily water discharge does not exceed 15 ppm • All non-biodegradable waste to be returned to shore for disposed at an approved shore reception facility • Schlumberger will ensure that a waste disposal log is maintained on all survey vessels	MARPOL Annex V and IV Maritime Transport Act 1994 Marine Protection Rules Part 170 EEZ Discharge & Dumping Regulations 2015 Resource Management (Mar Pol) Regulations 1998
Minimise effects on air quality	• Regular maintenance of machinery • Approved IAPPC where applicable to vessel class and regular monitoring of fuel consumption	International best practice
Minimise the likelihood of unplanned events	• Continuous Line Acquisition and around the clock operations reduce the overall duration of the survey • Comply with the COLREGS and have a support vessel present at all times • Approved SOPEP and IOPPC where applicable to vessel class • Refuelling will only occur during daylight and in good sea conditions, and will be constantly monitored • Transfer hoses will be fitted with 'dry-break' couplings • Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas • Radio communications will be maintained between the seismic vessel and support vessel during refuelling • Solid streamers used in conjunction with self-recovery devices	International best practice COLREGS Maritime Protection Rules Part 130A and 123A JHA for refuelling

7 CONCLUSION

Marine seismic surveys are considered to be routine activities within the oil and gas industry and are a prerequisite for the discovery of hydrocarbons beneath the seabed. During the proposed Pegasus Basin Seismic Survey, Schlumberger will comply with the Code of Conduct as the primary means of mitigating environmental effects. The STLM results has indicated that the standard mitigation zones within the Code of Conduct will protect marine mammals from both physiological and behavioural impacts.

In compliance with the Code of Conduct, Schlumberger will have two MMO's and two PAM operators on-board the seismic vessel. These personnel will be independent and qualified through DOC accredited training programmes. Visual observations will occur through daylight hours when the source is active and PAM operations to acoustically detect marine mammals will occur around the clock to enable detections of marine mammals at night. Depending on the circumstance and in keeping with the Code of Conduct, marine mammal detections will trigger the required mitigation actions, e.g. delayed start or shut downs of the source. In addition to the four qualified MMOs, Client has also made a commitment to local iwi groups to engage at least one trainee iwi MMO as a way of assisting these trainees towards becoming qualified.

In addition to the measures outlined in the Code of Conduct, Schlumberger will comply with all other relevant NZ legislation and international conventions (in relation to navigational safety, waste discharge, biosecurity etc.). Schlumberger has also proposed a number of extra management actions to further reduce the likelihood of environmental effects and to contribute to the knowledge of marine mammals in the proposed Operational Area.

This MMIA identifies all potential environmental effects from the Pegasus Basin Seismic Survey and describes all proposed mitigation measures that will be implemented to ensure that any potential effects are reduced to levels as low as reasonably practicable.

Although the MMIA focusses largely on potential marine mammal effects, potential effects on other components of the marine ecosystem and existing maritime activities are also considered and assessed through well-established ERA methodologies. In summary, the predicted effects of the Pegasus Basin Seismic Survey are considered to be ***low to medium***, with medium effects being sufficiently managed by the mitigation measures proposed in this MMIA.

8 REFERENCES

Aguilar de Soto, N, Delorme, N, Atkins, J, Howard, S, Williams, J & Johnson, M, 2013, '*Anthropogenic Noise Causes Body Malformations and Delays Development in Marine Larvae'*, Scientific Reports 3:2831.

Ahuriri Hapū, 2013, '*Agreement in Principle to Settle Historical Claims',* http://nz01.terabyte.co.nz/ots/DocumentLibrary/AhuririHapuAgreementinPrinciple.pdf

American Cetacean Society, 2016, '*Fact Sheet – Humpback Whales*', http://acsonline.org/fact-sheets/humpback-whale/

Andre, M, Soler, M, Lenoi, M, Dufrot, M, Quero, C, Alex, M, Antoni, L, Van Der Schar, M, Lopez-Bejar, M, Morell, M, Zaugg, S, & Houegnian, L, 2011, '*Low-frequency Sounds Induce Acoustic Trauma in Cephalopods'*, Frontiers in Ecology and the Environment, 9:489 – 493.

Andre, M, & Kamminga, C, 2000, '*Rhythmic Dimension in the Echolocation Click Trains of Sperm Whales, a Possible Function of Identification and Communication'*, Journal of the Marine Biological Association of the UK, 80:163 – 169.

Andriguetto-Filho, JM, Ostensky, A, Pei, MR, Silva, UA, & Boeger, WA, 2005, '*Evaluating the Impact of Seismic Prospecting on Artisanal Shrimp Fisheries*', Continental Shelf Research, 25:1720 – 1727.

Arnold, S. 2003, '*Shining a Spotlight on the Biodiversity of New Zealand's Marine Ecoregion*', Experts workshop on Marine Biodiversity. 27-28 May 2003, Wellington, New Zealand.

Aroyan, JL, McDonald, MA, Webb, SC, Hildebrand, JA, Clark, D, Laitman, JT, & Reidneberg, JS, 2000, '*Acoustic Models of Sound Production and Propagation'*, in '*Hearing by Whales and Dolphins'*, Eds: Au, WWL, Popper, N, & Fay, Springer, New York, US, p409 – 469.

Attard, C.R., Beheregaray, L.B., Jenner, K.C.S., Gill, P.C., Jenner, M.N., Morrice, M.G., Robertson, K.M. & Möller, L.M. 2012, '*Hybridization of Southern Hemisphere blue whale subspecies and a sympatric area off Antarctica: impacts of whaling or climate change?*', *Molecular Ecology*,*21*(23), pp.5715-5727.

Au, WL., Wursig, B (2004). Echolocation signals of dusky dolphins (*Lagenorhynchus obscurus*) in Kaikoura, New Zealand. Journal of the Acoustical Society of America 115: 2307 - 2313

Baco, A.R., Rowden, A.A., Levin, L.A., Smith, C.R., Bowden, D.A. 2010. '*Initial Characterisation of Cold Seep Faunal Communities on the New Zealand Hikurangi Margin'.* Marine Geology, 272: 251-259.

Baird, R.W. 2002, '*False Killer Whale'*, In Encyclopaedia of Marine Mammals. (Eds) Perrin, W.F., Wursig, B. & Thewissen, J.G.M. Elsevier Inc.

Baird, S.J., Tracey, D., Mormede, S., Clark, M. 2013. '*The Distribution of Protected Corals in New Zealand Waters'*. Prepared for DOC, NIWA Client Report No. WLG2012-43, 95p.

Baird, S, 2011, '*New Zealand Fur Seals – Summary of Current Knowledge'*, New Zealand Aquatic Environment and Biodiversity Report 72.

Baird, S.J. 2014. '*Ling Longline Effort and Catch Data Summary Relevant to Chatham Rise Phosphate Ltd Mining Permit and Licence Areas'*. Prepared for Chatham Rise Phosphate Ltd, NIWA Client Report No: WLG2014-11, 28p.

Baker, AN, 1999, '*Whales and Dolphins of New Zealand and Australia'*, Victoria University Press, Wellington, New Zealand.

Baker, AN, & Madon, B, 2007, '*Bryde's Whales (Balaenoptera cf brydei Olsen 1913) in the Hauraki Gulf and Northeastern New Zealand Waters'*, Science for Conservation: 272, Department of Conservation, Wellington, New Zealand, 23p.

Baker, CS, Chilvers, BL, Constantine, R, Du Fresne, S, Mattlin, RH, van Helden, A & Hitchmough, R, 2010, '*Conservation Status of New Zealand Marine Mammals (Suborders Cetacea and Pinnipedia)'*, New Zealand Journal of Marine and Freshwater Research, 44:101 – 115.

Baker, CS, Chilvers BL, Childerhouse, S, Constantine, R, Currey, R, Mattlin, R, van Helden, A, Hitchmough, R & Rolfe, J. 2016. '*Conservation status of New Zealand marine mammals, 2013'*. New Zealand Threat Classification Series 14. Department of Conservation, Wellington.

Ballara, SL., Anderson, OF. 2009. '*Fish Discards and Non-target Fish Catch in the Trawl Fisheries for Arrow Squid and Scampi in New Zealand Waters'*. New Zealand Aquatic Environment and Biodiversity Report No.38, 102 p.

Barrett-Lennard, L.G., Ford, J.K., & Heise, K.A. 1996, '*The Mixed Blessing of Echolocation: Differences in Sonar Use by Fish-eating and Mammal-eating Killer Whales'*, Animal Behaviour, 51(3): 553-565.

Beatson, E, O'Shea, S, & Ogle, M, 2007, '*First Report on the Stomach Contents of Long-finned Pilot Whales, Globicephala melas, Stranded in New Zealand'*, New Zealand Journal of Zoology, 34: 51 – 56.

Beatson, E. 2007. The diet of Pygmy Sperm Whales, Kogia breviceps, Stranded in New Zealand: Implications for Conservation. Rev. Fish. Biol. Fisheries 17: 295-303

Bendell, A, 2011, '*Shafag Asiman Offshore Block 3D Seismic Survey Exploration Survey – Environmental Impact Assessment'*, prepared for BP Azerbaijan, 23 August 2011, reference number P140167.

Bentley, J., Bishop, S., Marshall, A., McAuslan, B., Murray, C., Lucas, D., Baxter, A., McRae, S., Courtney, S., Rutledge, M., Clayton Greene, J., Duffy, C., Walls, G., Lynn, I. 2014. 'Natural Character of the Marlborough Coast – Defining and Mapping the Marlborough Coastal Environment'. Report prepared for Marlborough District Council.

Berkenbusch, K, Abraham, ER, & Torres, LG, 2013, '*New Zealand Marine Mammals and Commercial Fisheries'*, New Zealand Aquatic Environment and Biodiversity Report No. 119, Ministry for Primary Industries, Wellington, New Zealand, 113p.

Black, A, 2005, '*Light Induced Seabird Mortality of Vessels Operating in the Southern Ocean: Incidents and Mitigation Measures'*, Antarctic Science, 17:67 – 68.

Blackwell, SB, Nations, CS, McDonald, TL, Thode, AM, Mathias, D, Kim, KH, Greene, CR & Macrander, AM. 2015. '*Effects of airgun sounds on bowhead whale calling rates: evidence of two behavioural thresholds'*. PLoS ONE 10(6): e0125720.

Blue Planet Marine, 2014. Final Report – 2014 Schlumberger Seaco Inc. East Coast Pegasus Multiclient 2D Marine Seismic Survey. Report prepared for Schlumberger. Pp. 40.

Boeger, WA, Pie, MR, Ostrensky, A, & Cardaso, MF, 2006, '*The Effect of Exposure to Seismic Prospecting on Coral Reef Fishes'*, Brazilian Journal of Oceanography, 54(4):235 – 239.

Booth, J. D., and R. A. Stewart. 1992. 'Distribution of phyllosoma larvae of the red rock lobster Jasus edwardsii off the east coast of New Zealand in relation to the oceanography'. Bureau of rural resources proceedings, 15: 138-148.

Boubée, J.A.T., Mitchell, C.P., Chisnall, B.L., Bowman, E.J., Haro, A. 2001. 'Factors regulating the downstream migration of mature eels (Anguilla spp.) at Aniwhenua Dam, Bay of Plenty, New Zealand'. New Zealand Journal of Marine and Freshwater Research 35: 121-134

Boyd, P., Laroche,J., Gall, M., Frew, R., McKay, R.M.L. 1999. '*Role of iron, light, and silicate in controlling algal biomass in subantarctic waters SE of New Zealand*' Journal of geophysical research, 104(6): 13395-13408

Boren, L, 2005, '*New Zealand Fur Seals in the Kaikoura Region: Colony Dynamics, Maternal Investment and Health',* PhD Thesis, University of Canterbury.

Bowden, D.A., Rowden, A.A., Thurber, A.R., Baco, A.R., Levin, L.A., & Smith, C.R. 2013, 'Cold Seep Epifaunal Communities on the Hikurangi Margin, New Zealand: Composition, Succession, and Vulnerablility to Human Activties', PLoS ONE, 8(10): e76869. doi:10.1371/journal.pone.0076869

Bowles, AE., Smultea, M., Wursig, B., DeMaster, DP., Palka, D. 1994. Relative abundance and behaviour of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96: 2469 – 2484.

Boyd, S. 2009. '*Benthic Invertebrate Assemblages and Sediment Characteristics of Cold Seeps in the Hikurangi Margin, New Zealand*'. MSc Thesis. Auckland University of Technology.

Brabyn, MW, 1991, '*An Analysis of the New Zealand Whale Stranding Record'*, Science and Research Series No 20, Department of Conservation, Wellington, 53p.

Bradford, R.W., Bruce, B.D., Chiswell, S.M., Booth, J.D., Jeffs, A., & Wotherspoon, S. 2005. '*Vertical Distribution and Diurnal Migration Patterns of Jasus edwardsii Phyllosomas off the East Coast of the North Island, New Zealand'*, New Zealand Journal of Marine and Freshwater Research, 39:3, 593-604.

Bradford, J.M., & Champan, B.E. 1988, '*Epipelagic Zooplankton Assemblages and a Warm-core Eddy off East Cape, New Zealand'*, New Zealand Journal Plankton Research, 10(4): 601-619.

Bradford-Grieve, J.M., Boyd, P.W., Chang, F.H., Chiswell, S., Hadfield, M., Hall, J.A., James, M.R., Nodder, S.D., Shushkina, E.A. 1999. 'Pelagic ecosystem structure and functioning in the Subtropical Front region east of New Zealand in austral winter and spring 1993' Journal of Plankton Research, 21 (3): 405-428

Braham, HW, & Rice, DW, 1984, '*The Right Whale, Balaena glacialis'*, Marine Fisheries review, 46(4):38 – 44.

Brakes, P. & Dall, S.R.X. 2016. '*Marine Mammal Behaviour: A Review of Conservation Implications'*. Frontiers in Marine Science 3:87. doi: 10.3389/fmars.2016.00087.

Brodie, JW, 1960, '*Coastal Surface Currents Around New Zealand'*, New Zealand Journal of Geology and Geophysics, 3(2):235 – 252.

Buscaino, G, Filiciotto, Buffa, G, Bellante, A, Di Stefano, V, Assenza, A, Fazio, F, Caola, G, & Mazzola, S, 2010, '*Impact of an Acoustic Stimulus on the Motility and Blood Parameters of European Sea Bass (Dicentrarchus labrax) and Gilthead Sea Bream (Sparus aurata L)'*, Marine Environmental Research, 69:136 – 142.

Burtenshaw, JC, Olseon, EM, Hildebrand, JA, McDonald, MA, Andrew, RK, Howe, BM, & Mercer, JA, 2004, '*Acoustic and Satellite Remote Sensing of Blue Whale Seasonality and Habitat in the Northeast Pacific'*, Deep-sea Research II, 51:967 – 986.

Carey, WM, 2009, '*Lloyd's Mirror-Image Interference Effects'*, Acoustics Today, 5(2): 14 – 20.

Carpinter, B. & Joyce, D. 2010. Competing Claims for Moko the Dolphin's Remains. http://www.stuff.co.nz/national/3900065/Competing-claims-for-Moko-the-dolphins-remains

Carroll, E, Patenaude, N, Alexander, A, Steel, D, Harcourt, R, Childerhouse, S, Smith, S, Bannister, J, Constantine, R, & Baker, CS, 2011, '*Population Structure and Individual Movement of Southern Right Whales Around New Zealand and Australia'*, Marine Ecology Progress Series, 432:257 – 268.

Castellote, M., Clark, C.W. & Lammers, M.O. 2012. '*Acoustic and Behavioural Changes by Fin Whales (Balaenoptera physalus) in Response to Shipping and Airgun Noise'*. Biological Conservation 147: 115 – 122.

CentrePort. 2016. http://www.centreport.co.nz/

Cerchio, S., Strindberg, S., Collins, T., Bennett, C., Rosenbaum, H. 2014. Seismic surevys negatively affect humpback whale singing activity off Angola. PLOS ONE 9 (3): e86464.

Childerhouse, SJ, Dawson, SM, & Slooten, E, 1995, '*Abundance and Seasonal Residence of Sperm Whales at Kaikoura, New Zealand'*, Canadian Journal of Zoology, 73:723 – 731.

Chiswell, S.M. 2000. '*The Wairarapa Coastal Current'* New Zealand Journal of Marine and Freshwater Research, 34(2):303-315

Chiswell, S.M. 2002. '*Temperature and salinity mean and variability within the subtropical front over the Chatham rise, New Zealand'* New Zealand Journal of Marine and Freshwater Research, 36(2): 281-298

Chiswell, S.M. 2003, '*Circulation within the Wairarapa Eddy, New Zealand'*, New Zealand Journal of Marine and Freshwater Research, 37:4, 691-704.

Chrisp, S. 2002, '*Rangitāne o Wairarapa Traditional History',* Report no. Wai 863 #A60.

Codarin, A., Wysocki, L.E., Ladich, F., & Picciulin, M. 2009, '*Effects of Ambient and Boat Noise on Hearing and Communication in Three Fish Species Living in a Marine Protected Area (Miramare, Italy)',* Marine Pollution Bulletin 58(12):1880 – 1887.

Colman, JG, Grebe, CC, & Hearn, RL, 2008, '*The Challenges and Complexities of Impact Assessment for a Seismic Survey in a Remote Coral Reef Environment'*, IAIA08 Conference Proceedings, The Art and Science of Impact Assessments 28th Conference of the International Association for Impact Assessments, 4 – 10 May 2008, Perth Convention Exhibition Centre, Perth, Australia.

Consalvey, M., MacKay, K., Tracey, D. 2006. '*Information Review for Protected Deep Sea Coral Species in the New Zealand Region*'. Report no. WLG2006-85. Prepared by NIWA for the Department of Conservation.

Constantine, R, & Baker, C, 1997, '*Monitoring the Commercial Swim-with-dolphins Operations in the Bay of Islands'*, Science for Conservation 56, Department of Conservation, Wellington, New Zealand.

Constantine, R, Aguilar de Soto, N, & Johnson, M, 2012, '*Sharing the Waters: Minimising Ship Collisions with Bryde's Whales in the Hauraki Gulf*', Research Progress Report, February 2012, 22p.

Crawley, MC, & Wilson, 1976, '*The Natural History and Behaviour of the New Zealand Fur Seal (Arctocephals forsteri)'*, Tuatara, 22(1):1 – 29.

Croll, DA, Marinovic, B, Benson, S, Chavez, FP, Black, N, Ternullo, R, & Tershy, BR, 2005, '*From Wind to Whales: Trophic Links in a Coastal Upwelling System'*, Marine Ecology Progress Series, 289:117 – 130.

Cummings, WC, & Thompson, PO, 1971, '*Underwater Sounds from the Blue Whale. Balaenoptera musculus'*, Journal of the Acoustical Society of America, 50:1193 – 1198.

Currey, RJC, Boren, LJ, Sharp, BR, & Peterson, D, 2012, '*A Risk Assessment of Threats to Maui's Dolphins'*, Ministry for Primary Industries and Department of Conservation, Wellington, 51p.

Dalebout, M. L., Russell, C. G., Little, M. J. & Ensor, P. 2004. Observations of live Gray's beaked whales (Mesoplodon grayi) in Mahurangi Harbour, North Island, New Zealand, with a summary of at-sea sightings. Journal of the Royal Society of New Zealand 34: 347-356.

Davidson, R., Duffy, C., Gaze, P., Baxter, A., & DuFresne, S. 2011, 'Ecologically Significant Marine Sites in Marlborough, New Zealand', Published by Marlborough District Council, September 2011.

Dawbin, W.H. & Cato, D. 1992. Sounds of a Pygmy Right Whale (Caperea marginata). Marine Mammal Science 8(3): 213-219.

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M. 2016. Assessing the Impact of Marine Seismic Surveys on Southeast Australian Scallop and Lobster Fisheries. 19 October 2916. FRDC Project No 2012/008. http://www.frdc.com.au/research/Final_reports/2012-008-DLD.pdf

Debusschere, E, Hostens, K, Adriaens, D, Ampe, B, Botteldooren, D, De Boeck, G, De Muynck, A, Kumar Sinha, A, Vandendriessche, S, Van Hoorebeke, L, Vincx, M & Degraer, S. 2016. Acoustic Stress Responses in Juvenile Sea Bass *Dicentrarchus labrax* Induced by Offshore Pile Driving. Environmental Pollution 208: 747 – 757.

Deecke, VB, Ford, JKB, & Spong, P, 2000, '*Dialect Change in Resident Killer Whales: Implications for Vocal Learning and Cultural Transmission'*, Animal Behaviour, 60:629 – 638.

De Leo, F.C. 2012. '*Submarine Canyons: Hotspots of Deep-Sea Benthic Abundance and Biodiversity.*, PhD Thesis, University of Hawaii.

Deepwater Group, 2016. '*Fisheries*' http://deepwatergroup.org/

DeRonde, C.E.J., Baker, E.T., Massoth, G.J., Lupton, J.E., Wright, I.C., Feely, R.A., & Greene, R.R. 2001, 'Intra-Oceanic Subduction-Related Hydrothermal Venting, Kermadec Volcanic Arc, New Zealand', Earth and Planetary Science Letters, 193: 259-369.

Di Iorio, L, & Clark, C, 2009, '*Exposure to Seismic Surveys Alters Blue Whale Acoustic Communication'*, Biological Letters, 6:51 – 54.

DIR, 2007, '*Petroleum Guidelines – Minimising Acoustic Disturbance to Marine Fauna'*

DOC, 2007, '*Whales in the South Pacific'*, accessed from http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/whales-in-the-south-pacific.pdf

DOC, 2013, '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations'*, Department of Conservation.

DOC, 2015. Whale Survey Counts Record 137 Humpback Whales. http://www.doc.govt.nz/news/media-releases/2015/whale-survey-counts-record-137-humpback-whales/

DOC, 2016, '*Southern Right Whales/Tohora'*, accessed from http://www.doc.govt.nz/nature/native-animals/marine-mammals/whales/southern-right-whales-tohora/

DOC, 2016a, 'Whale Research in Cook Strait', accessed from http://www.doc.govt.nz/about-doc/news/media-releases/2014/whale-research-in-cook-strait/

DOC, 2016b, '*Dusky Dolphin*', http://www.doc.govt.nz/nature/native-animals/marine-mammals/dolphins/dusky-dolphin/

DOC, 2016c, '*Atlas of the Amphibians and Reptiles of New Zealand'*, accessed from http://www.doc.govt.nz/our-work/reptiles-and-frogs-distribution/atlas/

DOC, 2016d, '*Sea and Shore Birds of New Zealand'*, accessed from http://www.doc.govt.nz/nature/native-animals/birds/sea-and-shore-birds/

DOC, 2016e, http://www.doc.govt.nz/nature/habitats/marine/other-marine-protection/

DOC, 2016f, http://www.doc.govt.nz/nature/habitats/marine/other-marine-protection/clifford-and-cloudy-bay/

DOC, 2016g, http://www.doc.govt.nz/parks-and-recreation/places-to-go/hawkes-bay/places/te-angiangi-marine-reserve/

DOC, 2016h, http://www.doc.govt.nz/parks-and-recreation/places-to-go/wellington-kapiti/places/taputeranga-marine-reserve/

DOC, 2016i, http://www.doc.govt.nz/parks-and-recreation/places-to-go/marlborough/places/hikurangi-marine-reserve/

DOC, 2016j, http://www.doc.govt.nz/kaikoura-marine

DOC, 2016k, http://www.doc.govt.nz/nature/native-animals/marine-mammals/seals/elephant-seal/

DOC, 2016l. '*Eels*'. http://www.doc.govt.nz/nature/native-animals/freshwater-fish/eels/

DOSITS 2016. '*Discovery of Sound in the Sea'*. www.dosits.org/animals/useofsound

Du Fresne, S. & Mattlin, R. 2009. Distribution and abundance of Hector's dolphin (Cephalorhynchus hectori) in Clifford and Cloudy Bays. Final report for NIWA project CBF07401, Marine Wildlife Research Limited, Nelson, 28 p.

Dunlop, RA., Noad, MJ. McCauley, RD., Kniest, E., Slade, R., Paton, D., Cato, DH. 2016. Response of humpback whales (*Megaptera novaeangliae*) to ramp-up of a small experimental air gun array. Marine Pollution Bulletin 103: 72 – 83.

Ecan. 2005. 'Regional Coastal Environment Plan for the Canterbury Region – Volume 1'. Dated 30 November 2005.

Engas, A, Lokkeborg, S, Ona, E, & Soldal, A, 1996, '*Effects of Seismic Shooting on Local Abundance and Catch Rates of Cod (Gadus morhua) and Haddock (Melanogrammus aeglefinus)'*, Canadian Journal of Fisheries and Aquatic Sciences, 53:2238 – 2249.

Evans, K, & Hindell, MA, 2004, '*The Diet of Sperm Whales (Physeter macrocephalus) in Southern Australian Waters'*, Journal of Marine Science, 61:1313 – 1329.

Fewtrell, J, & McCauley, R, 2012, '*Impact of Air Gun Noise on the Behaviour of Marine Fish and Squid'*, Marine Pollution Bulletin, 64:984 – 993.

Fiedler, PC, Reilly, SB, Hewitt, RP, Demer, DA, Philbrick, VA, Smith, S, Armstrong, W, Croll, DA, Tershy, BR, & Mate, BR, 1998, *'Blue Whale Habitat and Prey in the California Channel Islands'*, Deep Sea Research Part II, 45:1781 – 1801.

Foote, A.D., Osborne, R.W., & Hoelzel, A.R. 2004, '*Environment: Whale-call Response to Masking Boat Noise'*, Nature 428: 910.

Forman, J., Mackenzie, A., Stotter, D 2014. '*Settlement indices for 2012 for the red rock lobster (Jasus edwardsii*)'. New Zealand Fisheries Assessment Report 2014/47. Ministry for Primary Industries, Wellington, New Zealand.

Forney, KA., Slooten, E., Baird, RW., Brownell, RL. Jnr., Southall, B., Barlow, J. 2013. Nowhere to go: effects of anthropogenic sound on small populations of harbour porpoise, Maui's dolphins, melon-headed whales and beaked whales. 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand, 9 – 13 December 2013.

Gailey, G., Wursig, B., McDonald, TL. 2007. Abundance, behaviour and movement patterns of western gray whales in relation to a 3D seismic survey, Northeast Sakhalin Island, Russia. Environ. Monit. Assess. 134: 75 – 91.

Gailey, G., Sychenko, O., McDonald, T., Racca, R., Rutenko, A., Broker, K. 2016. Behavioural responses of western gray whales to a 4-D seismic survey off north-eastern Sakhalin Island, Russia. Endangered Species Research 30: 53 – 71.

Garner, D.M. 1959. '*The sub-tropical convergence in New Zealand surface waters'* New Zealand Journal of Geology and Geophysic, 2(2): 315-337

Gaskin, DE, & Cawthorn, MW, 1967, '*Diet and Feeding Habitat of the Sperm Whale (Physeter catodon) in the Cook Strait Region of New Zealand'*, New Zealand Journal of Marine and Freshwater Research, 2:156 – 179.

Gausland, I, 2003, '*Seismic Surveys Impact on Fish and Fisheries'*, report for the Norwegian Oil Industry Association OLF.

Gibbs, N, & Childerhouse, S, 2000, '*Humpback Whales Around New Zealand'*, Conservation Advisory Science Notes Number 257, Department of Conservation, Wellington, New Zealand, 27p.

Gill, PC, Morrice, MG, Page, B, Pirzl, R, Levings, AH, & Coyne, M, 2011, '*Blue Whale Habitat Selection and Within-season Distribution in a Regional Upwelling System off Southern Australia'*, Marine Ecology Progress Series, 421:243 – 263.

Gomez-Villota, 2007, '*Sperm Whale Diet in New Zealand'*, unpublished MAppSc thesis, Division of Applied Sciences, Auckland University of Technology, Auckland, New Zealand, 221p.

Goold, J, 1996, '*Acoustic Assessment of Populations of Common Dolphins Delphinus delphis in Conjunction with Seismic Surveying'*, Journal of the Marine Biological Association of the UK, 76:811 – 820.

Goold, JC., Coates, RFW. 2006. 'Near source, high frequency air-gun signatures'. Paper SC/58/E30 presented to the IWC Scientific Committee, May 2006.

Gordon, J, Gillespie, D, Potter, J, Frantzis, A, Simmonds, MP, Swift, R, and Thompson, D, 2003, '*A Review of the Effects of Seismic Surveys on Marine Mammals*', Marine Technology Society Journal, 37(4):16 – 34.

Gorman, R, Chiswell, S, & Smith, M, 2005, '*Marine Weather and Sea Conditions of the Great South Basin'*, National Institute of Water and Atmosphere.

GWRC, 2000, 'Regional Coastal Plan for the Wellington Region', Prepared by Wellington Regional Council, Publication No. WRC/RP-G-00/02.

Haggit, T., Wade, O. 2016. 'Hawke's Bay Marine Information: Review and Research Strategy'. Report prepared for Hawke's Bay Regional Council, 113p.

Hammond, PS, Bearzi, G, Bjorge, A, Forney, K, Karczmarski, L, Kasuya, T, Perrin, WF, Scott, MD, Wang, JY, Wells, RS, & Wilson, B, 2008, '*Delphinus delphis. The IUCN Red List of Threatened Species. Version 2014.2"*. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T11146A3257285.en

Handegard, N, Tronstad, T, Hovem, J & Jech, J, 2013, '*Evaluating the Effect of Seismic Surveys on Fish – The Efficacy of Different Exposure Metrics to Explain Disturbance*', Canadian Journal of Fisheries and Aquatic Sciences, 70:1271 – 1277.

Harcourt, RG, 2001, '*Advances in New Zealand Mammalogy 1990 – 2000: Pinnipeds'*, Journal of the Royal Society of New Zealand, 31:135 – 160.

Harcourt, RG, Bradshaw, C, Dickson, K, & Davis, L, 2002, *'Foraging Ecology of a Generalist Predator, the Female New Zealand Fur Seal'*, Marine Ecology Progress Series, 227:11 – 24.

Hart et al, 2008. http://www.geog.canterbury.ac.nz/department/staff/deirdre/Hart%20et%20al%20Nat%20Histy%20chap20%20Coastal%20Systems.pdf

Hassel, A, Knutsen, T, Dalen, J, Skaar, K, Lokkeborg, S, Misund, O, Ostensen, O, Fonn, M, & Haugland, E, 2004, '*Influence of Seismic Shooting on the Lesser Sandeel (Ammodytes mariunus)'*, ICES Journal of Marine Science, 61:1165 – 1173.

HBRC, 2014, '*Hawke's Bay Regional Coastal Environment Plan: Operative'*, Dated 8 November 2014. http://www.hbrc.govt.nz/About-your-Council/Plans-Strategies/RCEP/Pages/default.aspx

Heath, R. A. 1985. '*A review of the physical oceanography of the seas around New Zealand - 1983*' New Zealand Journal of Marine and Freshwater Research, 19 (1): 79-124

Heretaunga Tamatea, 2015, '*Deed of Settlement of Historical Claims'* https://www.govt.nz/dmsdocument/6097.pdf

Heyning, J. E. 2002. Cuvier's beaked whale Ziphius cavirostris. In: W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), Encyclopedia of Marine Mammals, pp. 305-307. Academic Press, San Diego, USA.

Horizons, 2014, '*One Plan – the Consolidated Regional Policy Statement, Regional Plan and Regional Coastal Plan for the Manawatu-Wanganui Region'*, prepared by Horizons Regional Council, accessed from http://www.horizons.govt.nz/assets/publications/about-us-publications/one-plan/Horizons-Regional-Council-One-Plan.pdf

Horwood, J, 2009, '*Sei Whales Balaenoptera borealis'*, in '*Encyclopaedia of Marine Mammals'*, Eds Perrin, WF, Wursig, BG, & Thewissen, JGM, Academic Press, United States, p1001 – 1003.

Hurst, R.J., Stevenson, M.L., Bagley, N.W., Griggs, L.H., Morrison, M.A., Francis, M.P. 2000. '*Areas of Ecological Importance for Spawning, Pupping, or Egg-laying, and Juveniles of New Zealand Coastal Fish*'. Final Research Report for the Ministry of Fisheries, Research Project ENV1999/03.

IAGC, 2002, '*Marine Seismic Operations – An Overview'*, produced by IAGC to provide a reference to other marine operations in general and the fishing industry in particular, IAGC, March, 2002.

IWC. 2007. Report of the Scientific Committee. Annex K. Report of the Standing Working Group on Environmental Concerns. Journal of Cetacean Research and Management (Suppl.) 9: 227 – 296

Jackson, J.A., Carroll, E., Smith, T.D., Patenaude, N.J. & Baker, C.S. 2011. Taking Stock – the Historical Demography of the New Zealand Right Whale (the Tohora) 1820 – 2008. Pp. 35.

Jackson, JA, Steel, DJ, Beerli, P, Congdon, BC, Olavarria, C, Leslie, MS, Pomilla, C, Rosenbaum, H, & Baker, C, 2014, '*Global Diversity and Oceanic Divergence of Humpback Whales (Megaptera novaeangliae)'*, proceedings of the Royal Society B, 281:20133222.

Jackson, J.A., Carroll, E.L., Smith, T.D., Zerbini, A.N., Patenaude, N.J. & Baker, C.S. 2016. An integrated approach to historical population assessment of the great whales: case of the New Zealand southern right whale. Royal Society Open Science 3: 150669.

Jakupsstovu, S, Olsen, D, & Zachariassen, K, 2001, '*Effects of Seismic Activities at the Faroe Islands'*, accessed from http://www.hav.fo/PDF/Ritgerdir/2001/Ensk_seism_rapp.pdf

Jaquet, N., Dawson, S. & Slooten, E. 2000. '*Seasonal Distribution and Diving Behaviour of Male Sperm Whales off Kaikoura: Foraging Implications'*. Canadian Journal of Zoology 78(3): 407 – 419.

Jefferson, TA, Webber, MA, & Pitman, L, 2008, *'Marine Mammals of the World: a Comprehensive Guide to Their Identification',* Elsevier, 573p.

Jeffs, A.G., Chiswell, S.M., Booth, J.D. 2001. '*Distribution and Condition of Pueruli of the Spiny Lobster Jasus edwardii Offshore from Northeast New Zealand'*. Marine and Freshwater Research 52: 1211-1216.

Jensen, A, & Silber, G, 2004, *'Large Whale Ship Strike Database',* U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-OPR, 37p.

Johnson, M, Soto, N, & Madsen, P, 2009, '*Studying the Behavioural and Sensory Ecology of Marine Mammals Using Acoustic Recording Tags: A Review'*, Marine Ecology Progress Series, 395:55 – 73.

Johnson, SR., Richardson, WJ., Yazvenko, SB., Blokhin, SA., Gailey, G., Jenkerson, MR., Meier, SK., Melton, HR., Newcomer, MW., Perlov, AS., Rutenko, SA., Wursig, B., Martin, CR., Egging, DE. 2007. A western gray whale mitigation and monitoring program for a 3D seismic survey, Sakhalin Island, Russia. Environ. Monit. Assess. 134: 1 – 19.

Kato, H, 2002, '*Bryde's Whales'*, in '*Encyclopaedia of Marine Mammals'*, Eds Perrin, WF, Wursig, BG, & Thewissen, JGM, Academic Press, United States, p171 – 177.

Kelly, M. 2015. '*Splendid Sponges. A guide to the sponges of New Zealand'*. Available from https://www.niwa.co.nz/coasts-and-oceans/marine-identification-guides-and-fact-sheets/Splendid%20Sponges

Kemper, K. 2002. Distribution of the Pygmy Right Whale, Caperea marginata, in the Australasian Region. Marine Mammal Science 18(1): 99 - 111.

Kettles, H.A., Hughes, P.M., 2009. '*Wellington Marine Information: A Resource for Conservation, Planning and Research'*. CD-ROM. Wellington Conservancy, Department of Conservation, Wellington, New Zealand.

Koski, WR., Abgrall, P., Yazvenko, SB. 2009. '*A Review and Inventory of Unmanned Aerial Systems for Detection and Monitoring of Key Biological Resources and Physical Parameters Affecting Marine Life During Offshore Exploration and Production Activities'*. International Whaling Commission report SC/61/E9.

Kyhn, LA, Tougaard, J, Jensen, F, Whalberg, M, Stone, G, Yoshinga, A, Beedholm, K, & Marsden, PT, 2009, '*Feeding at High Pitch: Source Parameters of Narrow Band, High-frequency Clicks From Echo-locating Off-shore Hourglass Dolphins and Coastal Hector's Dolphins'*, Journal of the Acoustical Society of America, 125(3):1783 – 1791.

Labella, A, Cannata, S, Froglia, C, Ratti, S, & Rivas, G, 1996, '*First Assessment of Effects of Air-gun Seismic Shooting on Marine Resources in the central Adriatic Sea*', The Third International Conference on Health, Safety & Environment in Oil & Gas Exploration & Production, New Orleans, LA, 9 – 12 June 1996, New Orleans LA, US.

Ladich, F. and Fine, M.L. 2006. '*Sound-generating Mechanisms in Fishes: a Unique Diversity in Vertebrates'*. In Communication in Fishes, Vol. I (ed. F. Ladich, S. P. Colin, P. Moller and B. G. Kapoor), pp. 3-43. Enfield: Science Publishers.

Lalas, C, & Bradshaw, C, 2001, '*Folklore and Chimerical Numbers: Review of a Millennium of Interaction Between Fur Seals and Humans in the New Zealand Region'*, New Zealand Journal of Marine and Freshwater Research, 35:477 – 497.

Lalas, C, & McConnell, H, 2016, '*Effects of seismic surveys on New Zealand fur seals during daylight hours: Do fur seals respond to obstacles rather than airgun noise?*'. Marine Mammal Science 32(2) 643 – 663.

Lesage, V, Barrette, C, Kindgsley, M, & Sjare, B, 1999, '*The Effect of Vessel Noise on the Vocal Behaviour of Belugas in the St Lawrence River Estuary, Canada'*, Marine Mammal Science, 15:65 – 84.

Lettevall, E., Richter, C., Jaquet, N., Slooten, E., Dawson S., Whitehead, H., Christal, J. & McCall Howard, P. 2002. '*Social Structure and Residency in Aggregations of Male Sperm Whales'*. Canadian Journal of Zoology 80: 1189 – 1196.

Levin, L.A. 2005, '*Ecology of Cold Seep Sediments: Interactions of Fauna with Flow, Chemistry, and Microbes*', Oceanography and Marine Biology Annual Review, 43: 1-46.

Lörz, A.N., Berkenbusch, K., Nodder, S., Ahyong, S., Bowden, D., McMillan, P., Gordon, D., Mills, S., Mackay, K. 2012. '*A Review of Deep-sea Benthic Biodiversity Associated with Trench, Canyon and Abyssal Habitats Below 1500 m Depth in New Zealand Waters*'. New Zealand Aquatic Environment and Biodiversity Report No 92, 133 p

MacDiarmid, A., Nelson, W., Gordon, D., Bowden, D., Mountjoy, J., & Lamarche, G. 2012, '*Sites of Significance for Indigenous Marine Biodiversity in the Wellington Region',* NIWA Client Report No: WLG2012-19, Prepared for Greater Wellington Regional Council.

MacDiarmid, A., Nelson, W., Gordon, D., Bowden, D., Mountjoy, J., Lamarch, G. 2012. 'Sites of significance for indigenous marine biodiversity in the Wellington region. Prepared for Greater Wellington Regional Council'

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A. 2013. 'Sensitive Marine Benthic Habitats Defined', NIWA Client Report No: WLG2013-18, Prepared for Ministry for the Environment.

MacDuff-Duncan, C, & Davies, G, 1995, '*Managing Seismic Exploration in a Nearshore Environmentally Sensitive Area'*, Society of Petroleum Engineers, Offshore Europe, 5 – 8 September, Aberdeen, United Kingdom.

Macleod, C. D., Santos, M. B. and Pierce, G. J. 2003. Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 83: 651-665

MacKenzie, L, & Clement, DM, 2014, '*Abundance and Distribution of ECSI Hector's Dolphins'*, New Zealand Aquatic Environment and Biodiversity Report No. 123, Ministry Primary Industries, Wellington, New Zeeland.

MarineLife. 2016. http://www.marinelife.ac.nz/

Markowitz, T, Harlin, AD, Wursig, B, & McFadden, CJ, 2004, '*Dusky Dolphin Foraging Habitat: Overlap with Aquaculture in New Zealand'*, Aquatic Conservation: Marine and Freshwater Ecosystems, 14:133 – 149.

Marsden, I.D., & Schiel, D. 2007, '*Kaikoura Coast Literature Review',* Estuarine Research Report 32. University of Canterbury, Christchurch, New Zealand.

Marten, K. 2000. '*Ultrsonic analysis of Pygmy Sperm Whale (Kogia breviceps) and Hubbs' Beaked Whale (Mesoplodon carhubbsi) Clicks'*. Aquatic Mammals 26(1): 45 – 48.

Matsuoka, K., Fujise, Y. and Pastene, L. A. 1996. A sighting of a large school or the pygmy right whale, Caperea marginata, in the southeast Indian Ocean. Marine Mammal Science 12(4): 594-596.

Mattlin, R, Gales, N, & Coasta, D, 1998, '*Seasonal Dive Behaviour of Lactating New Zealand Fur Seals (Arctocephalus fosteri)'*, Canadian Journal of Zoology, 72(2):350 – 360.

Maungaharuru Tangitū, 2013, '*Deed of Settlement of Historical Claims'* http://nz01.terabyte.co.nz/ots/DocumentLibrary/Maungaharuru-TangituHapuDOS.pdf

Maxwell, K. 2012, '*Fisheries in the Ngati Kahungunu Rohe, New Zealand*', MSc Thesis, Victoria University, Wellington, New Zealand.

McCauley, R, 1994, '*Seismic Surveys'*, in '*Environmental Implications of Offshore Oil and Gas Developments in Australia, the Finding of Independent Scientific Review'*, Eds. Sawn, JM, Neff, JM, & Young, PC, Australian Petroleum Exploration Associated, Sydney, NSW.

McCauley, RD., Jenner, C., Jenner, MN., Murdoch, J, McCabe, K. 1998. The response of humpback whales to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal 2000: 692 – 708.

McCauley, RD, Fewtrell, J, Duncan, AJ, Jenner, C, Jenner, M-N, Penrose, JD, Prince, RIT, Adhitya, A, Murdoch, J, & McCabe, K, 2000, '*Marine Seismic Surveys – A Study of Environmental Implications*', APPEA Journal 2000, 692 – 708.

McCauley, R, Fewtrell, J, Duncan, A, Jenner, C, Jenner, M, Penrose, JD, Prince, R, Adhitya, A, Murdoch, J, & McCabe, K, 2003, '*Marine Seismic Surveys – Analysis and Propagation of Air-gun Signals in Environmental Implications of Offshore Oil and Gas Development in Australia: Further Research'*, APPEA Ltd.

McDonald, MA, Calambokidis, J, Teranishi, AM, & Hildebrand, JA, 2001, '*The Acoustic Calls of Blue Whales Off California with Gender Data'*, The Journal of Acoustical Society of America, 109:1728 – 1735.

McDonald, M.A. 2006. An Acoustic Survey of Baleen Whales off Great Barrier Island, New Zealand. New Zealand Journal of Marine and Freshwater Research 40:519-529.

McGregor, PK, Horn, AG, Leonard, ML, & Thomsen, F, 2013, '*Chapter 14: Anthropogenic Noise and Conservation'*, in '*Animal Noise and Conservation'*, Volume 2 of the Series Animal Signals and Communication, p409 – 444.

Mead, J. G. 1989. Beaked whales of the genus Mesoplodon. In: S. H. Ridgway and R. Harrison (eds), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales, pp. 349-430. Academic Press.

Meynier, L, Stockin, KA, Bando, MKH, & Duignan, PJ, 2008, '*Stomach Contents of Common Dolphins (Delphinus sp) from New Zealand Waters'*, New Zealand Journal of Marine and Freshwater Research, 42:257 – 268.

MFish, 2010. http://www.fish.govt.nz/NR/rdonlyres/06F3676E-BD74-4137-AE7E-57A0BDDCE819/0/Complianceinfosheet07.pdf

Miller, BS, Collins, K, Barlow, J, Calderan, S, Leaper, R, McDonald, M, Ensor, P, Olson, P, Olavarria, C, & Double, MC, 2013, '*Blue Whale Vocalisations Recorded Around South Island, New Zealand 1964 – 2013*', Journal of the Acoustical Society of America, 135:1616 – 1623.

Mills, S., Neil, K., Anderson, O., Davey, N. 2014. '*Extraordinary Echinoderms. A Guide to the Echinoderms of New Zealand. Version 1*'. Available from https://www.niwa.co.nz/coasts-and-oceans/tools-and-resources/Echinoderm%20ID%20Guide

Miyshita, T, Kato, H, & Kasuya, T, 1995, '*Worldwide Map of Cetacean Distribution Based on Japanese Sighting Data',* Volume 1, National Research Institute of Far Seas Fisheries, Shizuoka, Japan, 140p.

Mizroch, S. A., Rice, D.W., Breiwick, J.M. 1984, *'The fin whale, Balaenoptera physalus'*, Marine Fisheries Review 46 (4): 20 – 24

Moriyasu, M., Allain, R., Benhalima, K., Clator, R. 2004. *'Effects of seismic and marine noise on invertebrates: A literature Review'*. Canadian Science Advisory Secretariat. Research Document 2004/126.

Morrison, M.A., Jones, E.G., Parsons, D.P., Grant, C.M. 2014. '*Habitats and Areas of Particular Significance for Coastal Finfish Fisheries Management in New Zealand: A Review of Concepts and Life History Knowledge, and Suggestions for Future Research*'. New Zealand Aquatic Environment and Biodiversity Report No. 125, 205p.

MPI, 2014, '*Fisheries Assessment Plenary, May 2014: Stock Assessments and Stock Status'*, Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington New Zealand 1381 p.

MPI, 2014. '*East Coast North Island/Pegasus Basin Fisheries Summary – January 2014'.* Prepared for Schlumberger NZ Ltd. January 2014.

MPI, 2016. '*King Crab (KIC)'. http://fs.fish.govt.nz/Page.aspx?pk=7&tk=100&sc=KIC*

MPI. 2016a. '*Region – Central (East)(FMA2)'*. http://fs.fish.govt.nz/Page.aspx?pk=41&tk=404&fyk=37

MPI. 2016b. '*Region – South-east Coast (FMA3)'*. http://fs.fish.govt.nz/Page.aspx?pk=41&tk=404&fyk=39

MPI. 2016c. '*Fishery – East Coast North Island Shellfish'*. http://fs.fish.govt.nz/Page.aspx?pk=5&tk=1&fpid=21

MPI. 2016d. '*Fishery – Southern Shellfish*. http://fs.fish.govt.nz/Page.aspx?pk=5&tk=1&fpid=19

MPI, 2016e. '*New Zealand Orange Roughy. Sustainable New Zealand Seafood Fact Sheet',* February 2016, Ministry for Primary Industries, Wellington, New Zealand

MPI. 2016f. 'Deep-water Crab Fishery'. http://fs.fish.govt.nz/Page.aspx?pk=5&tk=1&fpid=18

MPI. 2016g. 'Red Rock Lobster Fishery'. http://fs.fish.govt.nz/Page.aspx?pk=5&tk=1&fpid=57

Mueller-Blenkle, C., McGregor, P.K., Gill, A.B., Andersson, M.H., Metcalfe, J., Bendall, V., Sigray, P., Wood, D., & Thomsen, F. 2010, 'Effects of Pile Driving Noise on the Behaviour of Marine Fish', COWRIE Ref: Fish 06-08 / Cefas Ref:C3371, Technical Report. 31 March 2010.

MyWeather2, 2016, '*Local Weather'*, accessed from http://www.myweather2.com/

NapierPort. 2016. http://napierport.co.nz/

NIWA. 2016. '*Tuna – tuna heke (downstream migrants)' https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/biology-and-ecology/migrant-tuna-tuna-heke*

Ngāti Kuia, 2010, '*Deed of Settlement of Historical Claims',* http://nz01.terabyte.co.nz/ots/DocumentLibrary/NgatiKuiaDeedofSettlement.pdf

Ngāti Pāhauwera, 2016, '*Takutai Moana',* http://ngatipahauwera.co.nz/takutai-moana/

Nowacek, D, Thorne, L, Johnston, D, & Tyack, P, 2007, '*Responses of Cetaceans to Anthropogenic Noise'*, Mammal Review, 37:81 – 115.

NZ Birds Online. 2016. '*New Zealand Birds Online – The Digital Encyclopaedia of New Zealand Birds*'. http://nzbirdsonline.org.nz/

NZGeo.com, 2016. '*The Humpback Highway'*, https://www.nzgeo.com/stories/the-humpback-highway/

NZP&M, 2016, '*New Zealand Petroleum & Minerals – Rules and Regulations'*, accessed from http://www.nzpam.govt.nz/cms/about-nzpam/rules-and-regulations

NZP&M, 2014, '*New Zealand Petroleum Basins'*, accessed from http://www.nzpam.govt.nz/cms/about-nzpam/doc-library/factsheets/petroleum-basins-part2.pdf

O'Callaghan, TM, Baker, AN, & Helden, A, 2001, '*Long-finned Pilot Whale Strandings in New Zealand – the Past 25 Years'*, Science Poster No. 25, Department of Conservation, Wellington, accessed from http://www.doc.govt.nz/Documents/science-andtechnical/SciencePoster52.pdf.

Oceanic Research Group, 2016, '*Sperm Whales – the Wonders of the Sea', http://www.oceanicresearch.org/education/wonders/spermwhales.htm*

O'Driscoll, R.L., Ballara, S.L. 2014. '*The Chatham Rise and Hoki – Role in Hoki Biology and Distribution'*. Prepared for Chatham Rock Phosphate, NIWA Client Report No. WLG2014-15, 33p.

O'Driscoll, R.L., Booth, J.D., Bagley, N.W., Anderson, O.F., Griggs, L.H., Stevenson, M.L., Francis, M.P. 2003. '*Areas of Importance for Spawning, Pupping or Egglaying, and Juveniles of New Zealand Deepwater Fish, Pelagic Fish, and Invertebrates'*. NIWA Technical Report 119, 377 p.

O'Driscoll, R. 2014. '*Statement of Evidence of Richard O'Driscoll for Chatham Rock Phosphate Limited*'. Dated 24 August 2014.

Olsen, PA, Ensor, P, Olavarria, C, Schmitt, N, Childerhouse, S, Constantine, R, Miller, BS, & Double, MC, 2013, '*New Zealand Blue Whales: Initial Photo-identification of a Little-known Population'*, Report to the Scientific Committee of the International Whaling Commission, SC/65a/Sh12.

Oshumi, S, & Kasamatsu, F, 1986, '*Recent Off-shore Distribution of the Southern Right Whale in Summer'*, Reports of the International Whaling Commission, Special Issue 10:177 – 186.

Patenaude, NJ, 2003, '*Sightings of Southern Right Whales Around 'Mainland' New Zealand'*, Science for Conservation 225, Department of Conservation, Wellington, New Zealand, 151p.

Parker, N, Maldenov, P, & Grange, K, 1997, '*Reproductive Biology of the Antipatharian Black Coral Antipathes fiodensis in Doubtful Sounds, Fiordland, New Zealand'*, Marine Biology, 130:11 – 22.

Parks, S, Johnson, M, Mowacek, D, & Tyack, PL, 2011, '*Individual Right Whales Call Louder in Increased Environmental Noise'*, Biology Letters, 7:33 – 35.

Parry, GD, & Gason, A, 2006, '*The Effect of Seismic Surveys on Catch Rates of Rock Lobsters in Western Victoria, Australia*', Fisheries Research, 79:272 – 284.

Payne, J, 2004, '*The Effects of Seismic Surveys on Fish Eggs, Larvae, and Zooplankton'*, Canadian Science Advisory Secretariat Research Document (CSAS).

Payne, JF., Andrews, CA., Fancey, LL., Cook, AL., Christian, JR. 2007. '*Pilot study on the effect of seismic airgun noise on lobster (Homarus americanus*)'. Can. Tech. Rep. Fish. Aquat. Sci 2712: v+46

PCE, 2013. '*On a Pathway to Extinction? An Investigation into the Status and Management of the Longfin Eel'*. A Report Prepared for the Parlimentary Commissioner of the Environment. April, 2013. Wellington, New Zealand. Pp. 95.

Pearson, W, Skalski, J, & Malme, C, 1992, '*Effects of Sounds from Geophysical Survey Devices on Behaviour of Captive Rockfish (Sebastes sp)'*, Canadian Journal of Fisheries and Aquatic Sciences, 49:1343 – 1356.

Perrin, WF, 2009, '*Minke Whales Balaenoptera acutorostrata and B. bonaerensis'*, in '*Encyclopaedia of Marine Mammals'*, Eds Perrin, WF, Wursig, BG, & Thewissen, JGM, Academic Press, United States, p733 – 735.

Pickett, G, Eaton, D, Seaby, R, & Arnold, G, 1994, '*Results of Bass Tagging in Poole Bay During 1992'*, Ministry of Agriculture, Fisheries, and Food Directorate of Fisheries Research, Laboratory Leaflet Number 71, 13p.

Pirotta, E., Brookes, KL., Graham, IM., Thompson, PM. 2014. Variation in harbour porpoise activity in response to seismic survey noise. Biology Letters 10: 20131090.

Popper, A, & Hastings, M, 2009, '*The Effects of Anthropogenic Sources of Sound on Fishes'*, Journal of Fish Biology, 75:455 – 489.

Popper, A, Smith, M, Cott, P, Hanna, B, MacGillivary, A, Austin, M, & Mann, D, 2005, '*Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species'*, Journal of the Acoustical Society of America, 117:3958 – 3971.

Port Nicholson Block 2008, '*Fisheries Protocol: Taranaki Whanui ki te Upoko o te Ika'*, Deed of Settlement Document Schedule, Protocol 1, http://www.fish.govt.nz/NR/rdonlyres/2093B27D-92A7-4240-84E8-B4A14797F347/0/TaranakiWhanuikiTeUpokooTeIkaFisheriesProtocol.pdf

Port Nicholson Block Settlement Trust, 2016, '*Welcome to the Port Nicholson Block Settlement Trust',* www.pnbst.maori.nz

Potter, JR., Thillet, M., Chitre, MA., Doborzynski, Z., Seekings, PJ. 2007 'Visual and passive acoustic marine mammal observations and high frequency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32: 469 – 483

Rankin, S. & Barlow, J. 2007. '*Vocalisations of the Sei Whale Balaenoptera borealis off the Hawiian Islands'*. Bioacoustics 16:137 – 145.

Raukura Consultants, 2015, '*Cultural Impact Report for Wellington Airport Ltd – South Runway Extension'*, Report prepared by Raukura Consultants, October 2015.

Rayment, W, Davidson, A, Dawson, S, Slooten, E, & Webster, T, 2012, '*Distribution of Southern Right Whales on the Auckland Island Calving Grounds'*, New Zealand Journal of Marine and Freshwater Research, 46:431 – 436.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008b. Caperea marginata. The IUCN Red List of Threatened Species 2008: e.T3778A10071743. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T3778A10071743.en. Downloaded on 14 August 2016.

Reilly, SB, Bannister, JL, Best, PB, Brown, M, Brownell Jr, RL, Butterworth, DS, Clapham, PJ, Cooke, J, Donovan, GP, Urban, J, & Zerbini, AN, 2008a, '*Balaenoptera bonaerensis. The IUCN Red List of Threatened Species 2008'*, accessed from http://www.iucnredlist.org/details/2480/0

Reilly, SB, Bannister, JL, Best, PB, Brown, M, Brownell Jr, RL, Butterworth, DS, Clapham, PJ, Cooke, J, Donovan, GP, Urban, J, & Zerbini, AN, 2008b, '*Balaenoptera borealis. The IUCN Red List of Threatened Species 2008'*, accessed from http://www.iucnredlist.org/details/2475/0

Reilly, SB, Bannister, JL, Best, PB, Brown, M, Brownell Jr, RL, Butterworth, DS, Clapham, PJ, Cooke, J, Donovan, GP, Urban, J, & Zerbini, AN, 2013, '*Balaenoptera physalus. The IUCN Red List of Threatened Species 2013'*, accessed from http://www.iucnredlist.org/details/2478/0

Rice, D, 1978, '*Blue Whale'*, in '*Marine Mammals of the Eastern Pacific and Antarctic Waters'*, Ed. Hayley, D, Pacific Search Press.

Richardson, WJ, Greene Jr, CR, Malme, CI, & Thompson, DH, 1995, '*Marine Mammals and Noise'*, Academic Press, San Diego, US, 576p.

Richter, C. F., Dawson, S.M. & Slooten, E. 2003. '*Sperm Whale Watching off Kaikoura, New Zealand: Effects of Current Activities on Surfacing and Vocalisation Patterns'*. Science for Conservation Report No. 219. Department of Conservation, Wellington, New Zealand.

Riekkola, L, 2013, '*Mitigating Collisions Between Large Vessels and Bryde's Whales in the Hauraki Gulf, New Zealand'*, a dissertation in partial fulfilment for the degree of Bachelor of Science with Honours, University of Auckland, New Zealand, 68p.

Robertson, H.A., Dowding, J.E., Elliott, G.P., Hitchmough, R.A., Miskelly, C.M., O'Donnell, C.F.J., Powlesland, R.G., Sagar, P.M., Scofield, R.P., Taylor, G.A. 2013. '*Conservation Status of New Zealand Birds, 2012*'. NZ Threat Classification Series 4, Department of Conservation, Wellington, New Zealand.

Robertson, FC., Koski, WR., Thomas, TA., Richardson, WJ., Wursig, B., Trites, AW. 2013a. Seismic operations have variable effects on dive-cycle behaviour of bowhead whales in the Beaufort Sea. Endangered Species Research 21: 143 – 160.

Roemmich, D., Sutton, P. 1998. 'The mean and variability of ocean circulation past northern New Zealand: Determining the representativeness of hydrographic climatologies' Journal of geophysical research, 103(6): 13041–13054

Rowantree, VJ, Valenzuela, LO, Fragus, PF, & Seger, J, 2008, '*Foraging Behaviour Southern Right Whales (Eubalaena australis) Inferred from Variation of Carbon Stable Isotope Ratios in Their Baleen'*, Report to the International Whaling Commission, SC/60/BRG23.

Royal Society of Canada, 2004, '*Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia'*, an Expert Panel Report Prepared by the Royal Society of Canada at the Request of Natural Resources Canada, Ottowa, ON.

Sagnol, O., Richter, C., Reitsma, F. & Field L.h. 2015. '*Estimating Sperm Whale (Physeter macrocephalus) Daily Abundance from a Shore-based Survey Within the Kaikoura Submarine Canyon, New Zealand*'. New Zealand Journal of Marine and Freshwater Research 49(1): 41 – 50.

Samaran, F., Adam, O. & Guinet, C. 2010, '*Discovery of a Mid-latitude Sympatric Area for Two Southern Hemisphere Blue Whale Subspecies*', Endangered Species Research, 12: 157-165.

Santulli, A, Modica, A, Messina, C, Ceffa, K, Curatolo, A, Rivas, G, Fabi, G, & D'Amelio, V, 1999, '*Biochemical Responses of European Sea Bass (Dicentrarchus labrax L) to the Stress Induced by Offshore Experimental Seismic Prospecting'*, Marine Pollution Bulletin, 38:1105 – 1114.

Scholik, A, & Yan, H, 2002, '*Effects of Boat Engine Noise on the Auditory Sensitivity of the Fathead Minnow, Pimphales promelas'*, Environmental Biology of Fishes, 63:203 – 209.

Scofield, P., Stephenson, B. 2013. '*Birds of New Zealand: A photographic Guide*'. Auckland University Press, Auckland, New Zealand.

SeaFIC, 2016, '*Species*'. Seafood Industry Council of New Zealand. http://www.seafood.co.nz/species/

Sekiguchi, K., Klages, N. T. W. and Best, P. B. 1996. The diet of strap-toothed whales (Mesoplodon layardii). Journal of Zoology (London) 239: 453-463.

Shirihai, H, & Jarrett, B, 2006, '*Whales, Dolphins and Other Marine Mammals of the World'*, Princeton University Press, Princeton, p56 – 58.

Simmonds, M, Dolman, S, & Weilgart, L, 2004, '*Oceans of Noise 2004'*, a Whale and Dolphin Conservation Science Report.

Simpson, SD, Radford, AN, Nedelec, SL, Ferrari, MCO, Chivers, DP, McCormick, MI & Meekan, MG. 2016. Anthropogenic noise increases fish mortality by predation. Nature Communications 7: 10544.

Sirovic, A, Hildebrand, JA, Wiggins, SM, McDonald, MA, Moore, SE, & Thiele, D, 2004, '*Seasonality of Blue and Fin Whale Calls and the Influence of Sea Ice in the Western Antarctic Peninsula'*, Deep Sea Research Part II: Tropical Studies on Oceanography, 51(17-19):2327 – 2344.

Skalski, J, Pearson, W, & Malme, C, 1992, '*Effects of Sounds From a Geophysical Device on Catch-per-unit-effort in a Hook-and-line Fishery for Rockfish (Sebastes sp)'*, Canadian Journal of Fisheries and Aquatic Sciences, 49:1357 – 1365.

Slooten, E., Rayment, W., Dawson, S. 2006. 'Offshore distribution of Hector's dolphins at Bank's Peninsula, New Zealand: Is the Banks Peninsula Marine Mammal Sanctuary large enough?', New Zealand Journal of Marine and Freshwater Research 40: 333-343.

Smith, ME, 2004, '*Noise-induced Stress Response and Hearing Loss in Goldfish (Carassius auratus)'*, Journal of Experimental Biology, 207:427 – 435.

Smith, P., & Paul, L. 2000. '*Stock Relationships of Alfonsino and Cardinalfish in New Zealand Waters'*, Final Research Report for Ministry of Fisheries Research Project DEE1999/03, Report prepared by NIWA, August 2000.

Snelder, T, Leathwick, J, Image, K, Weatherhead, M, & Wild, M, 2005, '*The New Zealand Marine Environmental Classification'*, NIWA Client Report: CHC2004-071, prepared for Ministry for the Environment.

Southall, B, Bowles, A, Ellison, W, Finneran, J, Gentry, R, Greene, C, Kastak, D, Ketten, D, Miller, J, Nachtigall, P, Thomas, J, & Tyack, P, 2007, '*Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations'*, Aquatic Mammals, 33.

Stanton, B.R. 1973. '*Hydrological investigations around northern New Zealand'* New Zealand Journal of Marine and Freshwater Research, 7(1-2): 85-110

Stone, C, & Tasker, M, 2006, '*The Effects of Seismic Airguns on Cetaceans in UK Waters*', Journal of Cetacean Research and Management, 8:255 – 263.

Sutton, P. 2001. '*Detailed structure of the Subtropical Front over Chatham Rise, east of New Zealand*' Journal of geophysical research, 106(12): 31045-31056

Sverdrup, A, Kjellsby, PG, Kruger, PG, Floys and, R, Knudsen, FR, Enger, PS, Serck-Hanssen, G, & Helle, KB, 1994, '*Effects of Experimental Seismic Shock on Vasoactivity of Arteries, Integrity of the Vascular Endothelium and on Primary Stress Hormones of the Atlantic Salmon*', Fish Biology, 45:973 – 995.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008. Mesoplodon bowdoini. The IUCN Red List of Threatened Species 2008: e.T13242A3425144. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13242A3425144.en. Downloaded on 14 August 2016.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008a. Mesoplodon grayi. The IUCN Red List of Threatened Species 2008: e.T13247A3428839. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13247A3428839.en. Downloaded on 14 August 2016.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008b. Mesoplodon layardii. The IUCN Red List of Threatened Species 2008: e.T13249A3429897. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13249A3429897.en. Downloaded on 14 August 2016

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008c. Mesoplodon hectori. The IUCN Red List of Threatened Species 2008: e.T13248A3429412. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13248A3429412.en. Downloaded on 15 August 2016.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008d. Tasmacetus shepherdi. The IUCN Red List of Threatened Species 2008: e.T21500A9291409. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T21500A9291409.en. Downloaded on 15 August 2016.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008e. *Ziphius cavirostris*. The IUCN Red List of Threatened Species 2008: e.T23211A9429826. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T23211A9429826.en. Downloaded on 15 August 2016

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J.K.B., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2012. Kogia breviceps. The IUCN Red List of Threatened Species 2012: e.T11047A17692192. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T11047A17692192.en. Downloaded on 14 August 2016.

Taylor, G.A. 2000. '*Action Plan for Seabird Conservation in New Zealand. Part A, Threatened Seabirds*'. Dept. of Conservation, Biodiversity Recovery Unit, Wellington, N.Z.

Te Ara , 1966 '*The Chatham Rise*' http://www.teara.govt.nz/en/1966/chatham-rise

Te Ara, 2016, '*Sea Floor Geology – The Continental Shelf*', accessed from http://www.teara.govt.nz/en/sea-floor-geology/page-3

Te Ara 2016a, '*Shellfish*', http://www.teara.govt.nz/en/shellfish/page-1

Te Ara, 2016b. '*Crabs, Crayfish and Other Crustaceans – Crustaceans – Bugs of the Sea'.* http://www.teara.govt.nz/en/crabs-crayfish-and-other-crustaceans/page-1

Te Ara. 2016c. '*Eels – Life Cycle and Breeding Grounds*'. http://www.teara.govt.nz/en/eels/page-3

Te Ara. 2016d, '*Whales*', http://www.teara.govt.nz/en/whales/page-5

Te Ara, 2016e. '*Ngati Kahungunu'* http://www.teara.govt.nz/en/ngati-kahungunu/page-1

Te Ara, 2016f, '*Ngāti Toa Rangatira'*. http://www.teara.govt.nz/en/ngati-toarangatira

Te Ara, 2016g. '*Te Whanau Puna – Whales'*. http://www.teara.govt.nz/en/te-whanau-puha-whales

Te Ara. 2016h. '*Coastal Fish – New Zealand's Coastal Fish'*. http://www.teara.govt.nz/en/coastal-fish/page-1

Telfer, T, Sincock, J, Bryd, G, & Reed, J, 1987, '*Attraction of Hawaiian Seabirds to Lights: Conservation Efforts and Effect of Moon Phase'*, Wildlife Society Bulletin, 15:406 – 413.

Te Atiawa o Te Waka-a-Māui, 2012, '*Deed of Settlement of Historical Claims'* http://nz01.terabyte.co.nz/ots/DocumentLibrary/TeAtiawaDeedofSettlement.pdf

Te Tau Ihu, 2014, '*Te Tau Ihu Statutory Acknowledgements 2014'*, Statutory Acknowledgements of the Resource Management Plans for Marlborough District Council, Nelson City Council, and Tasman District Council.

Te Wairoa, 2016. Deed of Settlement of Historical Claims between The Iwi and hapu of Te Rohe o Te Wairoa and Trustees of the Tatau Tatau o Te Wairoa Trust and the Crown. https://www.govt.nz/dmsdocument/6454.pdf

The Prow, 2016, '*The Tangata Whenua Tribes of Te Tau Ihu'*, accessed from http://www.theprow.org.nz/maori/the-tangata-whenua-tribes-of-te-tau-ihu/#.Vi7Y5X4rJhE

Thomas, J, Kastelein, R, & Supin, A, 1992, '*Marine Mammal Sensory Systems'*, Plenum Press, New York.

Thompson, P, Brookes, K, Graham, I, Barton, T, Needham, K, Bradbury, G, Merchant, N, 2013, '*Short-term Disturbance by a Commercial Two-dimensional Seismic Survey Does Not Lead to Long-term Displacement of Harbour Porpoises'*, Proceedings of the Royal Society B: Biological Sciences, 280.

Thompson, D. 2014. '*Statement of Evidence for Dr David Thompson for Chatham Rock Phosphate Limited*'. Dated 25 August 2014.

Thomsen, F, Franck, D, & Ford, JKB, 2001, '*Characteristics of Whistles From the Acoustic Repertoire of Resident Killer Whales (Orcinus orca) off Vancouver Island, British Columbia'*, Journal of the Acoustical Society of America, 109(3):1240 – 1246.

TKTTM, 2008, '*Kaikoura Coastal Marine Values and Uses: a Characterization Report'*, Produced by Te Korowai o Te Tai o Makokura (Kaikoura Coastal Marine Gaurdians), Revised Second Edition, May 2008, http://www.teamkorowai.org.nz/docs/Kaikoura_Coastal_Marine_Values_and_Uses_Second_edition_Low_Res.pdf

Todd, B, 2014, '*Whales and Dolphins of Aotearoa New Zealand'*, Te Papa Press, Wellington, New Zealand.

Tormosov, DD, Mikhaliev, YA, Best, PB, Zemsky, VA, Sekiguchi, K, & Brownell Jr, RL, 1998, '*Soviet Catches of Southern Right Whales Eubalaena australis, 1951 – 1971. Biological Data and Conservation Implications'*, Biological Conservation, 86(2):185 – 197.

Torres, L.G., Smith, T.D., Sutton, P., MacDiarmid, A. & Bannister, J. 2011. Habitat use and Distribution Patterns of Southern Right Whales and Sperm Whales Discerned from Spatial Analyses of 19th Century Whaling Records. NIWA Client Report WL2011-52. Pp. 135.

Torres, L, 2012, '*Marine Mammal Distribution Patterns off Taranaki, New Zealand, with Reference to the OMV New Zealand Limited Petroleum Extraction in the Matuku and Maari Permit Areas'*, report prepared by NIWA for OMV New Zealand Limited, March 2012, Report Number WLG2012-15.

Torres L. 2013. Evidence for an unrecognised blue whale foraging ground in New Zealand. New Zealand Journal of Marine & Freshwater Research. http://dx.doi.org/10.1080/00288330.2013.773919.

Torres, L.G., Halliday, J. & Sturman, J. 2013. Distribution Patterns of Cetaceans on the Chatham Rise. NIWA Report No: CRP12302, prepared for Chatham Rock Phosphate. Wellington, New Zealand. Pp. 46.

Torres, L. G., P. C. Gill, B. Graham, D. Steel, R. M. Hamner, C. S. Baker, R. Constantine, P. Escobar-Flores, P. Sutton, S. Bury, N. Bott, and M. H. Pinkerton. 2015. Population, habitat and prey characteristics of blue whales foraging in the South Taranaki Bight, New Zealand. SC/66a/SH6, International Whaling Commission.

Torres, L., & Klinck, H. 2016. Blue whale ecology in the South Taranaki Bight region of New Zealand: January-February 2016 Field Report. Oregon State University. March 2016.

Tracey D.M., Anderson O.F., Naylor J.R. 2011. '*A Guide to Common Deepsea Invertebrates in New Zealand Waters. Third Edition*'. New Zealand Aquatic Environment and Biodiversity Report No. 86.

Tumapuhia, 2013, '*Report regarding Treaty of Waitangi Claim Wai429',* http://www.tumapuhia.org.nz/Draft-Report-Feedback-Apr2013.pdf

Veirs, S., Veirs, V. & Wood, J. 2016. '*Ship Noise Extends to Frequencies Used for Echolocation by Endangered Killer Whales'*. PeerJ 4:e1657; DOI 10.7717/peerj.1657.

Visser, IN, 2000, '*Orca (Orcinus orca) in New Zealand Waters'*, PhD Dissertation, University of Auckland, New Zealand.

Visser, IN, 2007, '*Killer Whales in New Zealand Waters: Status and Distribution with Comments on Foraging'*, unpublished report (SC/59/SM19) to the Scientific Committee, International Whaling Commission.

Waitangi Tribunal, 2016, '*Mohaka te Awa Ngati Pahauwera te Iwi'* http://www.justice.govt.nz/tribunals/waitangi-tribunal/Reports/wai0119/doc_005

Wakefield, A.T., & Walker, L. 2005, '*Maori Methods and Indicators for Marine Protection: Ngati Kere Interests and Expectations for the Rohe Moana'*, New Zealand Department of Conservation, Ngati Kere and Ministry for the Environment, Wellington, New Zealand. 66 p.

Wale, MA, Simpson, SD & Radford, AN. 2013. Noise negatively affects foraging and antipredator behaviour in shore crabs. Animal Behaviour 86: 111 – 118.

Wale, MA, Simpson, SD & Radford, AN. 2013a. Size-dependant physiological responses of shore crabs to single and repeated playback of ship noise. Biological Letters 9: 20121194.

Wardle, C, Carter, T, Urquhart, G, Johnstone, A, Ziolkowski, A, Hampson, G, & Mackie, D, 2001, '*Effects of Seismic Air Guns on Marine Fish'*, Continental Shelf Research, 21:1005 – 1027.

Webb, C, & Kempf, N, 1998, '*Impact of Shallow-water Seismic in Sensitive Areas'*, Society of Petroleum Engineers Technical Paper, SPE 46722.

Webster, TA, Dawson, SM, Rayment, WJ, Parks, SE, Van Parijs, SM. 2016. Quantitative Analysis of the Acoustic Repertoire of Southern Right Whales in New Zealand. Journal of the Acoustical Society of America 140 (1): 322 – 333.

Weir, CR. 2008. Short-finned pilot whales (*Globicephala macrorhynchus*) respond to an airgun ramp-up procedure off Gabon. Aquatic Mammals 34: 349 – 354.

Wiseman, N, Parsons, S, Stockin, KA, & Baker, CS, 2011, '*Seasonal Occurrence and Distribution of Bryde's Whales in the Hauraki Gulf, New Zealand'*, Marine Mammal Science, 27:E252 – E267.

Woodside, 2007, '*Impacts of Seismic Airgun Noise on Fish Behaviour: A Coral Reef Case Study'*.

Wursig, B., Lynn, SK., Jefferson, TA., Mullin, KD. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24: 41 – 50.

Wursig, B, Duprey, N, & Weir, J, 2007, '*Dusky Dolphins (Lagenorhynchus obscurus) in New Zealand Waters: Present Knowledge and Research Goals'*, Department of Conservation Research and Development Series: 270, Department of Conservation, Wellington, New Zealand, 28p.

Yasvenko, SB., McDonald, TL, Blokhin, SA., Johnson, SR., Melton, HR., Newcomer, MW., Nielson, R., Wainwright, PW. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environ. Monit. Assess. 134: 93 – 106.

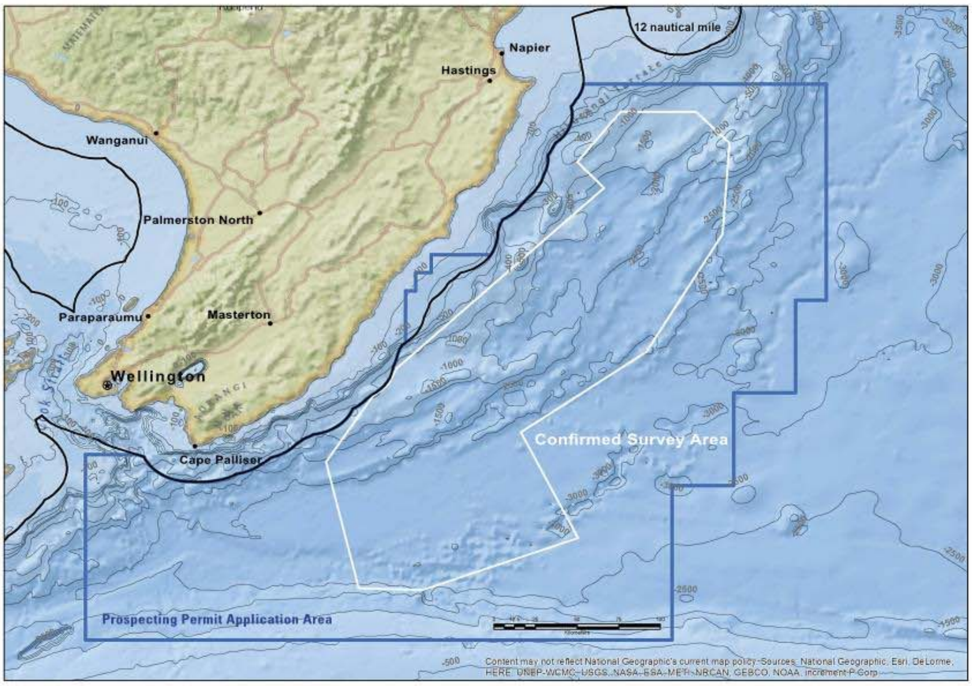
Zaeschmar, J, Visser, IN, Fertl, D, Dwyer, S, Meissner, AM, Halliday, J, Berghan, J, Donnelly, D, & Stockin, KA, 2013, '*Occurrence of False Killer Whales (Pseudocra crassidens) and Their Association with Common Bottlenose Dolphins (Tursiops truncatus) off Northeastern New Zealand'*, Marine Mammal Science, 30:594 – 608.

Zeldis, J.R., Murdoch, R.C., Cordue, P.L., & Page, M.J. 1998, '*Distribution of Hoki (Macruronus novaezelandiae) Eggs, Larvae, and Adults off Westland, New Zealand, and the Design of an Egg Production Survey to Estimate Hoki Biomass',* Canadian Journal of Fisheries and Aquatic Sciences 55: 1682–1694.

INFORMATION SHEET

Pegasus Geophysical Survey

Information for the local community



Schlumberger New Zealand (SNZL) will be conducting a geophysical survey in the Pegasus and East Coast basin off the east coast of New Zealand's North Island. The survey will be carried out by WesternGeco, the seismic business of Schlumberger, to gather geological information on potential oil and gas reservoirs. The survey will be conducted under a prospecting permit from New Zealand Petroleum and Minerals.

A WesternGeco purpose-built seismic vessel will collect data over an offshore area of about 16,000 km² generally from Hastings to Cape Palliser. The project is expected to begin in November 2016 and continue for about six months, depending on weather.

A WesternGeco crew will operate the geophysical equipment onboard the survey vessel, while a New Zealand marine crew will be onboard the survey, support and scout vessels. The project plays an important role in the New Zealand government's plan to create jobs and growth through unlocking the area's petroleum potential, and follows close consultation with the New Zealand government, iwi and local communities.

Environmental responsibility

Schlumberger understands its environmental responsibilities and is an industry leader in conducting safe geophysical operations in environmentally sensitive areas. An environmental impact assessment is being conducted to ensure the protection of marine life, and all seismic activity will adhere to the Department of Conservation's strict Code of Conduct for minimising acoustic disturbance to marine mammals.

Passive Acoustic Monitoring will be undertaken 24 hours a day during operations to detect the presence of marine mammals. Two independent trained Marine Mammal Observers and two Passive Acoustic Monitoring system operators will be onboard at all times.

In addition, Schlumberger intends to provide sea time for iwi trainees to facilitate qualification on Passive Acoustic Monitoring / Marine Mammal Observation for their future employment opportunities. These trainees will join the qualified observers onboard the vessel as part of their training and to increase visual observations during the survey.

Schlumberger experience

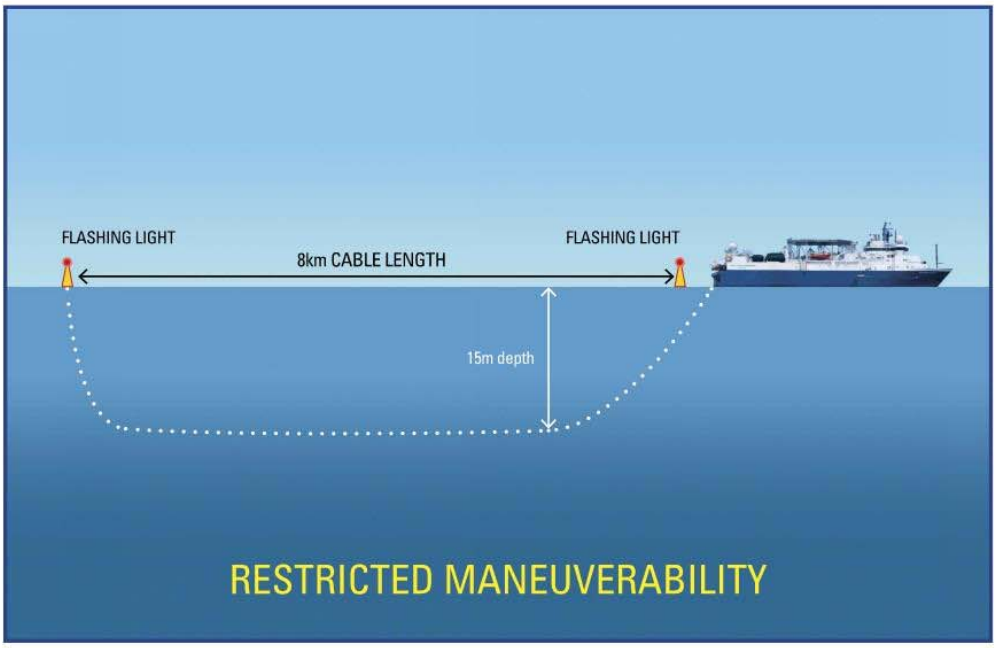
Schlumberger WesternGeco has a reputation for acquiring geophysical data with minimal stakeholder objection due to active stakeholder engagement with key groups including local iwi. We acquired the initial data in the Pegasus and East Coast basin area in 2014, and in 2013 completed the North Taranaki basin geophysical survey off the west coast of New Zealand.

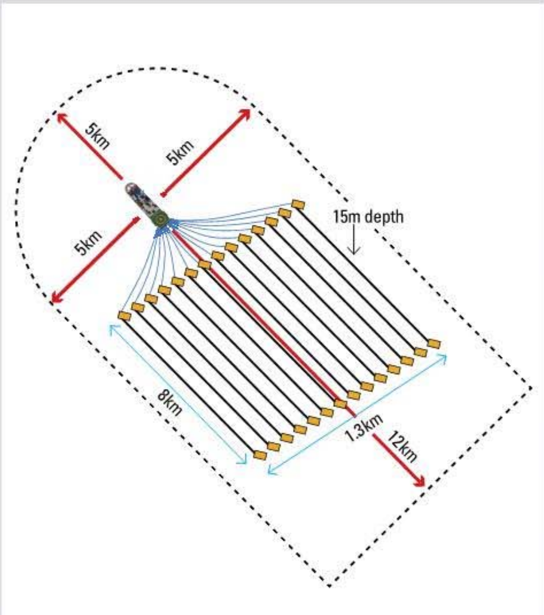
We have conducted successful marine surveys in North America, Latin America, Europe, Africa, Southeast Asia and Australia, including in some of the world's most environmentally sensitive areas.

For more information, please contact Schlumberger Multiclient environmentNZ@slb.com

INFORMATION SHEET

Survey Parameters





NOTICE TO FISHERMEN:

Schlumberger will be conducting a geo-physical survey in the Pegasus and East Coast basins off the east coast of North Island from November 2016 – May 2017 (expected completion). A purpose-built seismic vessel will conduct the survey, towing 14 cables, 8 km long and 15m below the water surface.

The cables contain electronics and can damage fishing gear if crossed. The boat is slow-moving (less than 5 knots) and has restricted maneuverability, so please give her a wide berth. Stay clear at least **12km astern, 5km abeam** and **5km ahead**. VHF operating channel will be 74 with constant monitoring on channel 16.

Stakeholder	Means	Date	Feedback	Schlumberger Commitments
Hawke's Bay Regional Council	Email	05.09.2016	Unable to meet face-to-face but will respond with any questions after reviewing the information sheet.	Provide information sheet
Maungaharuru Tangitu Trust	Phone call	05.09.2016	A meeting was initially scheduled, however this was then cancelled. Principle reasons was some of the members role in the East Coast Conservation Strategy where it was stated that any engagement with oil and gas operators while involved with this project would be conflicted.	-
Ngati Kahungunu ki Taraua	Phone call and Email	05.09.2016	Contact made to attempt to arrange a meeting, messages were left but no response was received.	-
Ngati Kahungunu ki Wairarapa – Tamaki Nui a Rua Trust	Phone call and Email	05.09. 2016	Contact made to attempt to arrange a meeting, messages were left but no response was received.	-
Te Runanga o Ngai Tahu	Meeting	05.09. 2016	A good general discussion about the proposed survey and Operational area. It was stated that Ngati Kuri's (Kaikoura) preference is for no exploration work and in general the Pegasus Basis, as it is considered to be of high risk to iwi from hydrocarbon exploration. Ngai Tahu wish to be a part of continued exploration in the Pegasus Basin and have their observers on the boat should the seismic survey go ahead.	Consider providing opportunity for iwi observers. SLB to discuss with GNS to see if there is any global exploration activity where there are similar formations and active plates. Actual survey acquisition lines to be shared with Ngai Tahu once finalised.
Ngati Kahungunu ki Wairarapa – Masterton Office	Meeting	06.09. 2016	An overview of the proposed survey was provided. It was stated that iwi feel it is good to have the relationship with operators and when it gets to the 'nitty gritty' of the exploration phase, this is when iwi will say things that they are not happy with. The office is choosing to engage to learn more about the seismic process, rather than protesting. More people are starting to accept seismic as long as	-

			operations are completed within the regulatory requirements. Main fear of iwi is if something goes wrong. Stated that operators need to address philosophical issues and communication needs to be consistent and transparent – and that an operator having people on the ground is important to them.	
Rangitane o Wairarapa – Masterton Office	Meeting	06.09. 2016	Stated that Rangitane's main concerns are the environment, fishing industry, and underdeveloped fisheries (surf clams), and that they do not detect any environmental impacts from seismic actives but will be more interested once production activities commence. Would like to know if king crabs are present in the Pegasus region and if seismic data will be made available to iwi to explore this resource. They hope that the operations will provide employment opportunities for Rangitane members.	Consider providing bathymetry data following survey. Consider providing opportunity for iwi observers.
Ngati Kahungunu – ki Tamaki Nui a Rua	Meeting	07.09. 2016	Would like to know more about the oil and gas industry in order to make better informed decisions and wish to be involved. Iwi observers are available and would like these people to be involved to give iwi some comfort. Want to ensure that seismic operations provide benefits to the region, not just iwi. Requested a monthly or 6 monthly email update during the survey. Requested that the MMO report to be sent through and a follow up meeting to be held once seismic operations are complete.	Consider providing opportunity for iwi observers. Provide updates during the survey. Provide the MMO report at survey completion. Consider a post-survey follow-up meeting.
Te Taiwhenua o Heretaunga	Meeting	29.09. 2016	A meeting was held of a large number of marae representatives from within Te Taiwhenua o Heretaugha. They consider that consultation at a hapu/marae level is appropriate. Generally opposed to oil and gas, as they understand that seismic	-

			exploration could lead to drilling. Feel that companies should be paying for information about traditional Maori knowledge. Concerns were raised about effects on fish.	
Deepwater Group	Meeting	08.09. 2016	Main concerns raised were 1) fisheries surveys – if occurring during seismic, data collection could be compromised, 2) displacement of stock when seismic vessel is in the area, and 3) scampi being killed or burrows collapsing as a result of seismic.	SLB to provide an approximate Operational Area for distribution to fishing industry. 48 hours notice of vessel location will be provided to Richard Wells who will then distribute to all fishers to minimise potential conflict. Determine whether any acoustic/trawl surveys – which there are not. Undertake a fisheries assessment with MPI to determine any potential conflict with the Operational Area and the scampi fishing grounds.
Environmental Protection Authority and Department of Conservation Wellington	Meeting	08.09. 2016	DOC's preference is to have one big survey as opposed to having multiple smaller surveys and stated that beaked whales will be in the area but unlikely to be seen or heard. Weekly MMO reports are often requested to be submitted to DOC and the EPA although this is not a requisite of the Code of Conduct. EPA may undertake vessel inspection offshore if required as the vessel will be in port for only a short time.	Provide weekly reports. Liaise with the EPA re vessel inspection.
Greater Wellington Regional Council	Meeting	09.09. 2016	No concerns were raised but SLB to provide council with a fact sheet which can be passed on to anyone with issues.	Provide information sheet.
Department of Conservation - Napier	Meeting	12.09. 2016	No concerns were raised but DOC recommended additional iwi/groups to engage with. SLB to provide an information sheet.	Provide information sheet. Undertake consultation with recommended iwi groups

Ngati Kahungunu Iwi Inc	Meeting	12.09. 2016	Iwi have a trained MMO that they wish to have involved in the survey. Raised concerns over the scampi fishery and suggested engagement with Fisheries Inshore. MMO report to be made available after the survey. Are keen to dispel some of the myths that go with the oil and gas industry and are interested in having the leaders see the seismic vessel. Information sheet to be provided once finalised.	Consider providing opportunity for iwi observers. Provide MMO report following survey completion. Provide information sheet. Consider inviting iwi to visit vessel.
Barine Developments	Emails	29.09. 2016 – 3.10. 2016	Ongoing email correspondence with regards to potential overlap with scampi fishing grounds.	Contact MPI to undertake fisheries assessment to assess the potential for spatial overlap between the Operational Area and the scampi grounds
Taranaki Whanui o te Upoko o te kia	Email and phone	1.09. 2016	Email and phone call to request a meeting. Due to a busy schedule they were unable to meet, were going to refer someone else to contact us but that did not get a response.	
Te Hika o Papauma	Email and phone	1.09. 2016	Email and phone call to request a meeting. However no response was received	
He Toa Takitini	Email and phone	10.09. 2016	Email and phone messages were left, but no response was received.	
Mana Ahuruiri Incorporated	Email	10.09. 2016	Email was sent with a request to meet. None of the listed phone numbers worked. No response was received.	
NIWA – Kim Goetz	Email	1.09.17	An email was sent to Kim providing details of the proposed survey as NIWA have an array of hydrophones deployed around the Cook Strait and Pegasus Basin region, one of which is within the Operational Area. Kim provided further location details and when they are going to be serviced. Kim will liaise with SLB	

			before the instruments are serviced and provide an updated location once redeployed. The hydrophones are moored on the seabed and will be released via an acoustic release, so there is no risk of any entanglement due to no surface moorning.	
Poronia Hineana Te Rangi Whanau	Meeting	17.10.16	A meeting was held with the Poronia Hineana Te Rangi Whanau who currently have a Marine and Coastal Area (MACA) application in with the government. As part of this application there is statutory notification/consultation rights to the iwi, hapū or whanau. Details were provided of the proposed survey and how it relates to their MACA application. A number of questions were asked and answers provided on seismic surveys, what they involve and the regulations by which they are conducted. It was generally concluded, based on their own research and discussions with SLB, that what is being proposed is being done around the world and they did not foresee too many issues with the project.	

SOUND TRANSMISSION LOSS MODELLING RESULTS

Sound Transmission Loss Modelling

Schlumberger 3D Seismic Survey

Pegasus Basin

Report Number 740.10032.AU001
13 October 2016

Schlumberger New Zealand Limited
94 Paraite Road
New Plymouth 4373
New Zealand

Version: v1.0

Schlumberger 3D Seismic Survey

Pegasus Basin

Sound Transmission Loss Modelling

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
740.10032.AU001	v1.0	13 October 2016	Binghui Li	Dan Govier Helen McConnell	Dan Govier

Executive Summary

Schlumberger New Zealand Limited (SLB) proposes to undertake a 3D marine seismic survey in the Pegasus Basin.

This report details the STLM study that has been carried out for the proposed survey, which includes the following three modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the array source, including its directivity characteristics;
- Short range modelling, i.e. prediction of the received sound exposure levels (SELs) over a range of a few kilometres from the array source location, in order to assess whether the proposed survey complies with the regulatory mitigation zone SEL requirements, and
- Long range modelling, i.e. prediction of the received SELs over a range of tens to hundreds of kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (e.g. the Clifford and Cloudy Bay Marine Mammal Sanctuary and the Kaikoura Whale Sanctuary).

The detailed modelling methodologies and procedures for the above components are described in **Section 2** and **Section 3** of the report.

The acoustic source array configuration that will be used for the Pegasus Basin Seismic Survey is the Delta 3 broadband 5,085 cubic inch array. The array comprises 3 sub-arrays, and each sub-array is the WesternGeco's proven 1,695 cubic inch array, having 8 acoustic source elements arranged as either single acoustic sources or in clusters. The array has an average towing depth of 7.0 m and an operating pressure of 2,000 pounds per square inch (PSI). The array source modelling illustrates distinctive array directivity of angle and frequency dependence for the energy radiation from the array, as a result of interference between signals from different array elements, particularly the three sub-arrays.

The short range modelling predictions using worst case modelling conditions (i.e. the seasonal sound speed profile of autumn and silty seabed sediment) demonstrates that the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.0 km for the two selected source locations. Although the volume of the seismic source array is comparatively large, the deep water within the survey area (minimum 400 m) and relatively weak directivities of the source array result in energy emissions from the source dissipating more evenly over the water column and azimuths.

The long range modelling shows that the received SELs at long range vary at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and particularly the propagation effects caused by bathymetry and sound speed profile variations.

The received noise levels within the Clifford and Cloudy Bay Marine Mammal Sanctuary from the adjacent selected source location are predicted to be below 100 dB re 1µPa^2·S. For the Kaikoura Whale Sanctuary, the received noise levels are predicted to be up to 115 dB re 1µPa^2·S. At the nearest 12 nautical miles offshore boundaries to the two selected source locations, the received noise levels are predicted to be up to 110 - 120 dB re 1µPa^2·S.

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APPENDICES

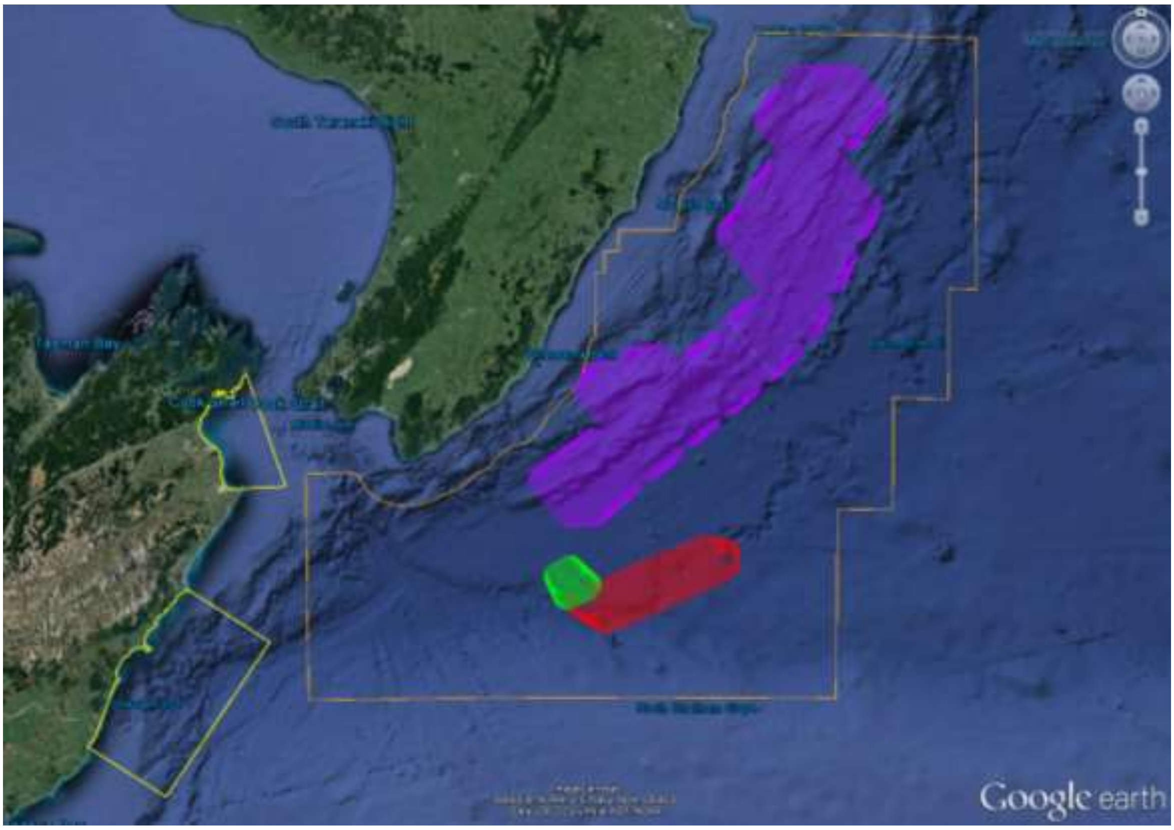
1 INTRODUCTION

1.1 Project description

Schlumberger New Zealand Limited (SLB) proposes to undertake a 3D marine seismic survey in the Pegasus Basin which includes three survey areas, as shown in **Figure 1**.

The Sound Transmission Loss Modelling (STLM) has been undertaken for the proposed survey, in order to predict the received Sound Exposure Levels (SELs) from the survey. The modelling outputs will also be used to demonstrate whether the survey complies with the SEL statutory requirements within the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code).

Figure 1 SLB Pegasus Basin 3D marine seismic survey areas (3 survey areas with survey lines of different colors (magenta, red and green)). Brown polygon defines the permit application area. Yellow polygons indicate the Clifford and Cloudy Bay Marine Mammal Sanctuary and the Kaikoura Whale Sanctuary.



1.2 Statutory requirements for sound transmission loss modelling (STLM)

In New Zealand, the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) was developed by the Department of Conservation (DOC) in consultation with a broad range of stakeholders in marine seismic survey operations. The Code came into effect on 29 November 2013.

The Code requires STLM to be undertaken to determine whether received SELs exceed 171 dB re $1\mu Pa^2.s$ (behaviour criteria) at ranges of 1.0 km and 1.5 km from the source and 186 dB re $1\mu Pa^2.s$ (injury criteria) at a range of 200 m from the source.

1.3 Structure of the report

This STLM study includes the following three modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the array source, including its directivity characteristics;
- Short range modelling, i.e. prediction of the received SELs within a range of a few kilometres from the array source location, in order to assess whether the proposed survey complies with the near-field mitigation zone requirements imposed by the Code, and
- Long range modelling, i.e. prediction of the received SELs over a range of tens to hundreds of kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (e.g. the Clifford and Cloudy Bay Marine Mammal Sanctuary and Kaikoura Whale Sanctuary).

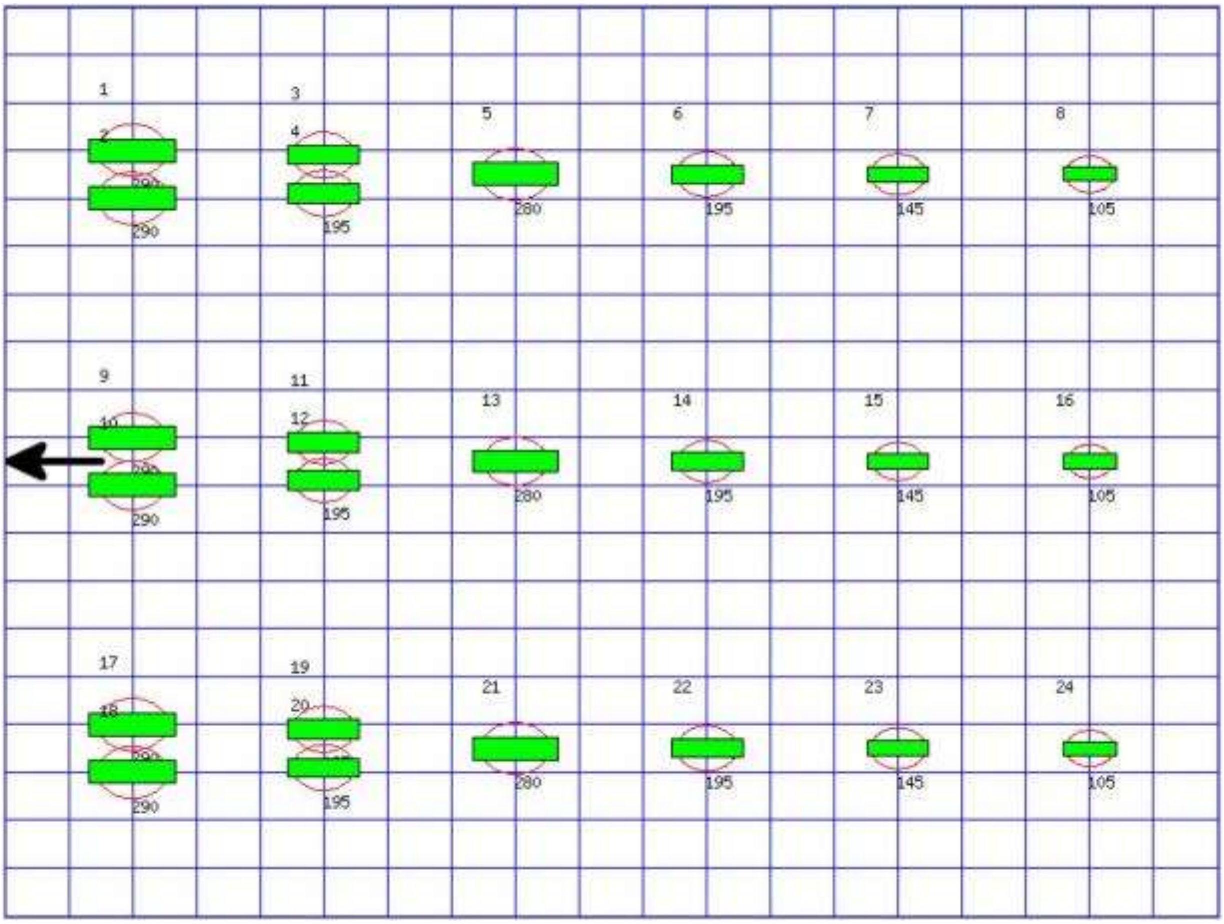
Section 2 of this report details the modelling methodology, procedure and results for the array source modelling. **Section 3** outlines the methodologies and procedures associated with the short and long range transmission loss modelling, with the major modelling results presented in **Section 4**. Relevant acoustic terminologies throughout the report are presented in **Appendix A**.

2 ACOUSTIC SOURCE ARRAY SOURCE MODELLING

2.1 Acoustic source array configuration

The acoustic source array that will be used for the seismic survey is the Delta 3 broadband 5,085 cubic inch array and its configuration is shown in **Figure 2**. The array comprises 3 sub-arrays, and each sub-array is the WesternGeco's proven 1,695 cubic inch array, having 8 acoustic source elements arranged as either single acoustic sources or in clusters. For all 24 elements of the acoustic source array either 1500LL or 1900LLX acoustic sources have been selected. The array has an average towing depth of 7.0 m and an operating pressure of 2,000 pounds per square inch (PSI).

Figure 2 The configuration (layout and volumes) of the Delta 3 broadband 5,085 cubic inch source array in a 1 m-grid plan view. The black arrow indicates the survey travel direction.



2.2 Modelling methodology

The required outputs of the acoustic source array source modelling for the subsequent sound modelling predictions include:

- A set of "notional" signatures for each of the array elements; and
- The far-field signature of the acoustic source array and its directivity/beam patterns.

2.2.1 Notional signatures

The notional signatures are the pressure waveforms of each individual acoustic source, accounting for its interaction with other source elements in the array, at a standard reference distance of 1 m.

Notional signatures are modelled using the Gundalf Designer software package (2016). The Gundalf acoustic source array source model is developed based on the fundamental physics of the oscillation and radiation of acoustic source bubbles as described by Ziolkowski (1970), taking into account non-linear pressure interactions between acoustic sources (Ziolkowski et al., 1982; Dragoset, 1984; Parkes et al., 1984; Vaages et al., 1984; Laws et al., 1988 & 1990).

The model solves a complex set of differential equations combining both heat transfer and dynamics, and has been calibrated against multiple measurements of both non-interacting acoustic sources and interacting cluster sources for all common acoustic source types at a wide range of deployment depths.

2.2.2 Far-field signatures

The notional signatures from all acoustic sources in the array are combined using appropriate phase delays in three dimensions to obtain the far-field source signature of the array. This procedure to combine the notional signatures to generate the far-field source signature is summarised as follows:

- The distances from each individual acoustic source to nominal far-field receiving location are calculated. A 9 km receiver set is used for the current study;
- The time delays between the individual acoustic sources and the receiving locations are calculated from these distances with reference to the speed of sound in water;
- The signal at each receiver location from each individual acoustic source is calculated with the appropriate time delay. These received signals are summed to obtain the overall array far-field signature for the direction of interest; and
- The far-field signature also accounts for ocean surface reflection effects by inclusion of the "surface ghost". An additional ghost source is added for each acoustic source element using a sea surface reflection coefficient of -1.

2.2.3 Beam patterns

The beam patterns of the acoustic source array are obtained as follows:

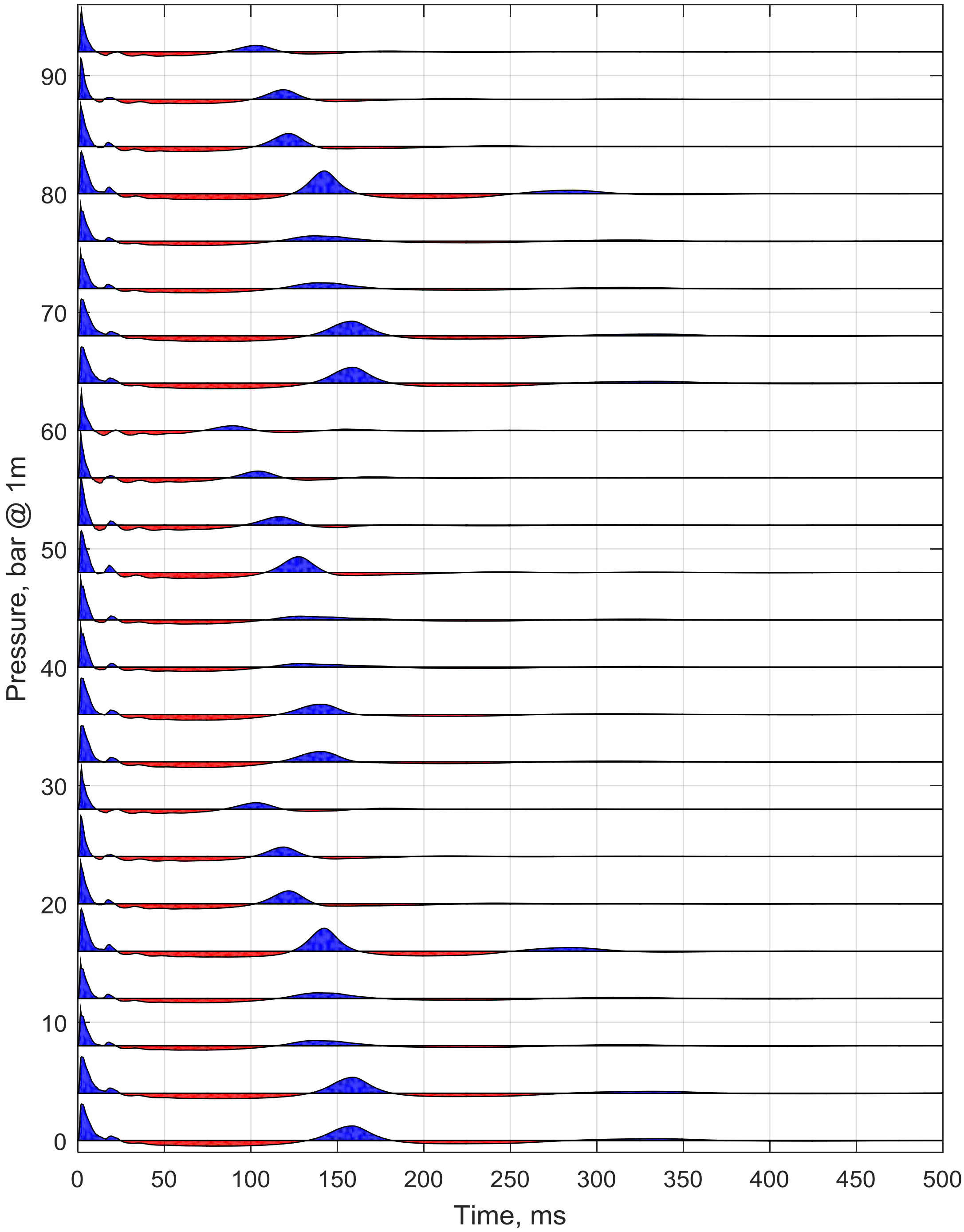
- The far-field signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The power spectral density (PSD) (dB re 1 $\mu Pa^2 s/Hz$ @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of all resulting signature waveforms are combined to form the frequency-dependent beam pattern for the array.

2.3 Modelling results

2.3.1 Notional signatures

Figure 3 shows the notional signatures for the 24 acoustic sources (8 acoustic sources per sub-array) of the Delta 3 broadband 5,085 cubic inch array.

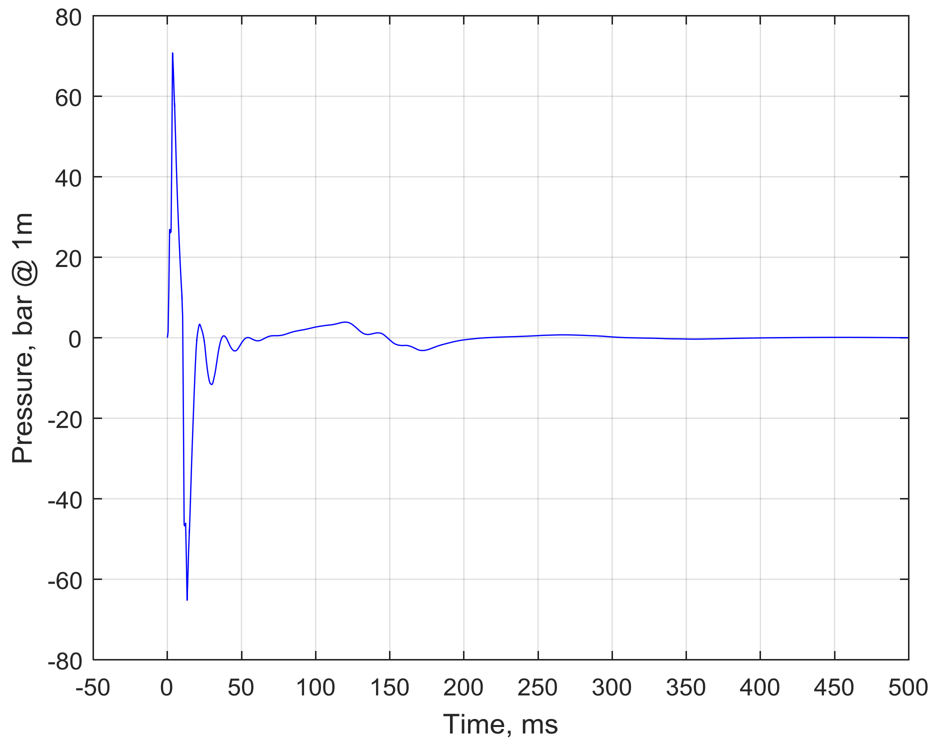
Figure 3 **Notional source signatures for each individual acoustic source within the 24-acoustic source unit (3 sub-arrays) Delta 3 broadband 5,085 cubic inch array. Time series of positive pressure and negative pressure indicated by blue fill and red fill respectively. The relative pressure scale is the same for the signatures from all acoustic sources.**

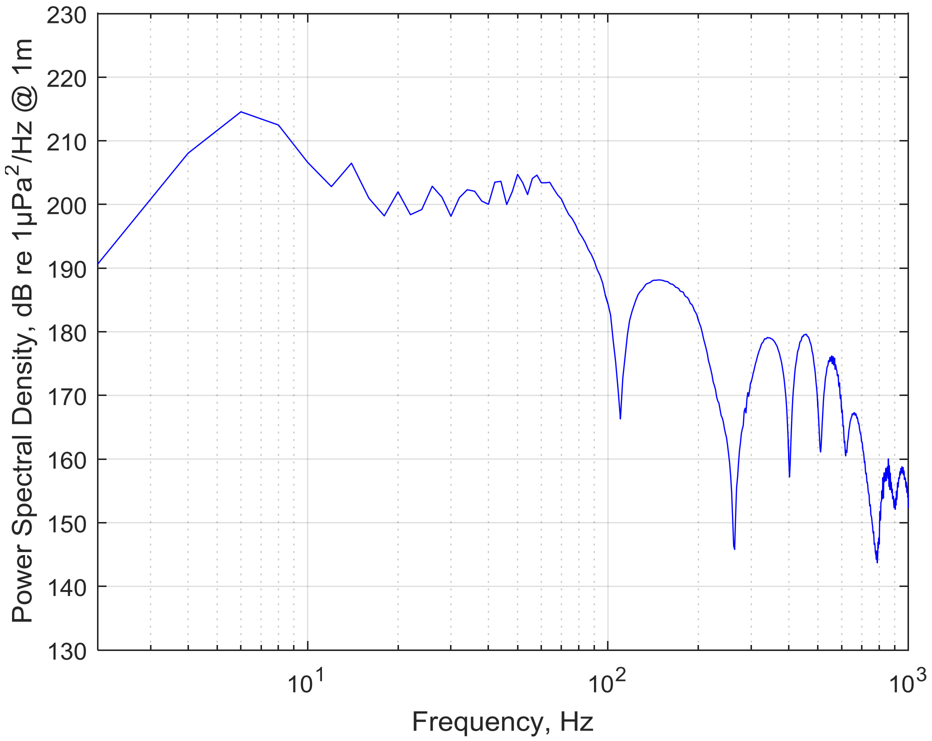


2.3.2 Far-field signatures

Figure 4 shows the simulated signature waveform based on Gundalf Designer software and its power spectral density. The signatures are for the vertically downward direction with surface ghost included.

Figure 4 The far-field signature in vertically downward direction (top) and its power spectral density (bottom) for the Delta 3 broadband 5,085 cubic inch array.





2.3.3 Beam patterns

Array far-field beam patterns of the following three cross sections are presented in **Figure 5**:

a) The horizontal plane (i.e. dip angle of 90 degrees) with azimuthal angle of 0 degree corresponding to the in-line direction;

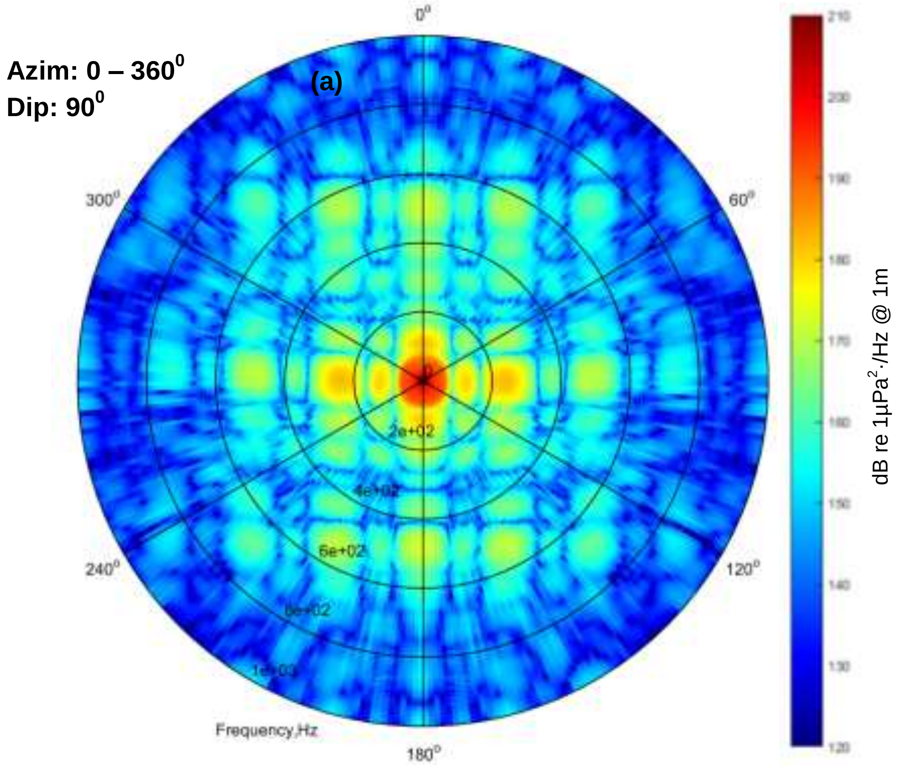
b) The vertical plane for the in-line direction (i.e. azimuthal angle of 0 degree) with dip angle of 0 degree corresponding to the vertically downward direction; and

c) The vertical plane for the cross-line direction (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

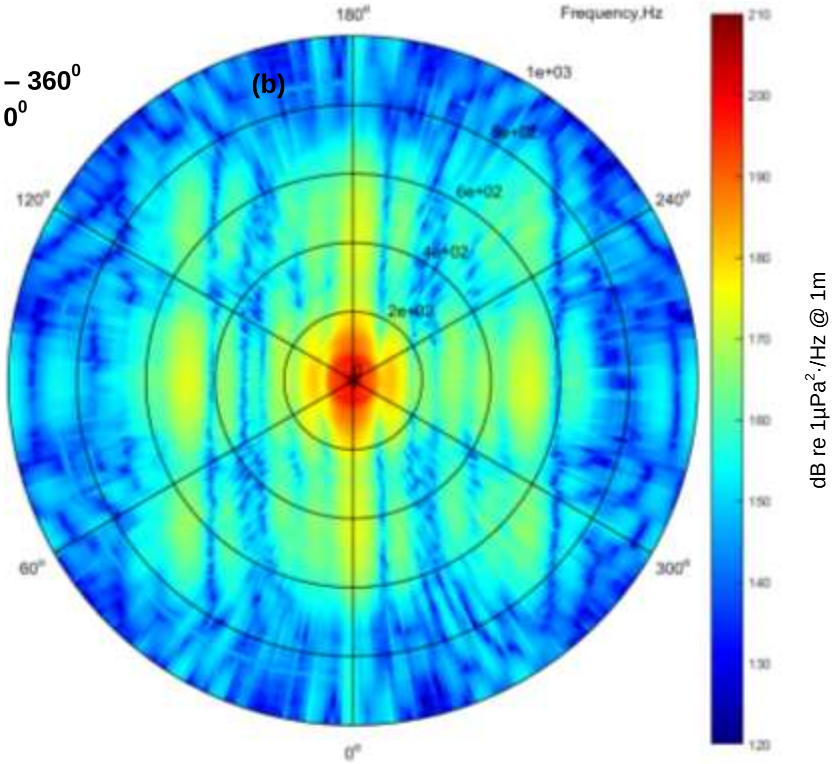
The beam patterns in **Figure 5** illustrate the strong angle and frequency dependence of the energy radiation from the array. The beam pattern of the horizontal plane shows relatively stronger energy radiation in the cross-line direction than in the in-line direction. The beam patterns of the in-line and cross-line vertical planes show relatively stronger radiation in the vertical direction.

The predominant frequency variation characteristics of these beam patterns are a result of interference between signals from different array elements, particularly from the three sub-array elements.

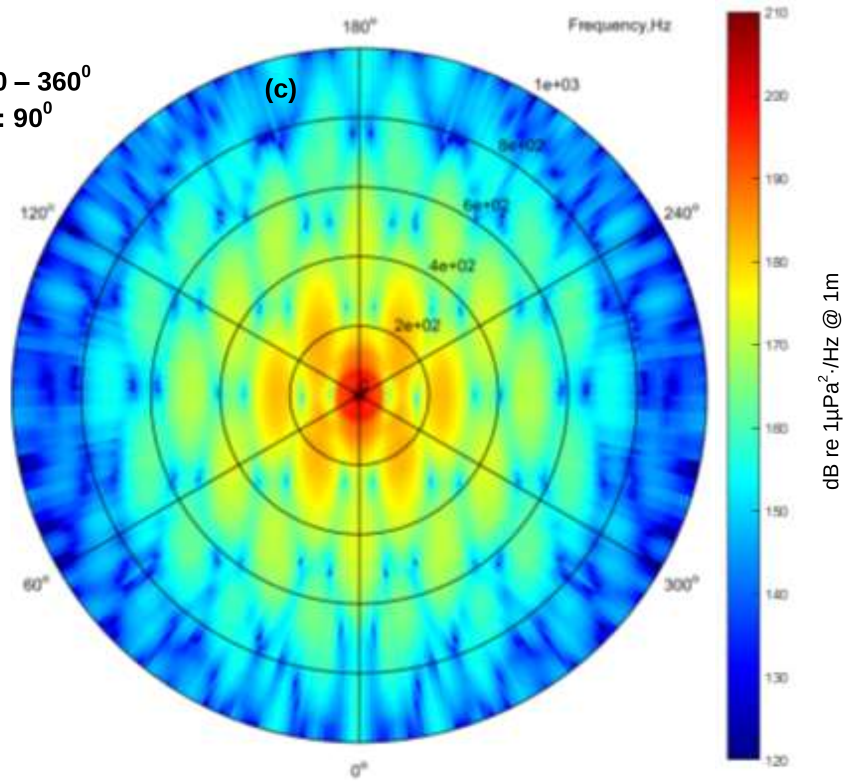
Figure 5 Array far-field beam patterns for the Delta 3 broadband 5,085 cubic inch array, as a function of orientation and frequency. (a) - The horizontal plane with 0 degree corresponding to the in-line direction; (b) – The vertical plane for the in-line direction; (c) – The vertical plane for the cross-line direction. 0 degree dip angle corresponds to vertically downward direction.



Dip: 0 – 360^0
Azim: 0^0



Dip: 0 – 360^0
Azim: 90^0



3 TRANSMISSION LOSS MODELLING

3.1 Modelling input parameters

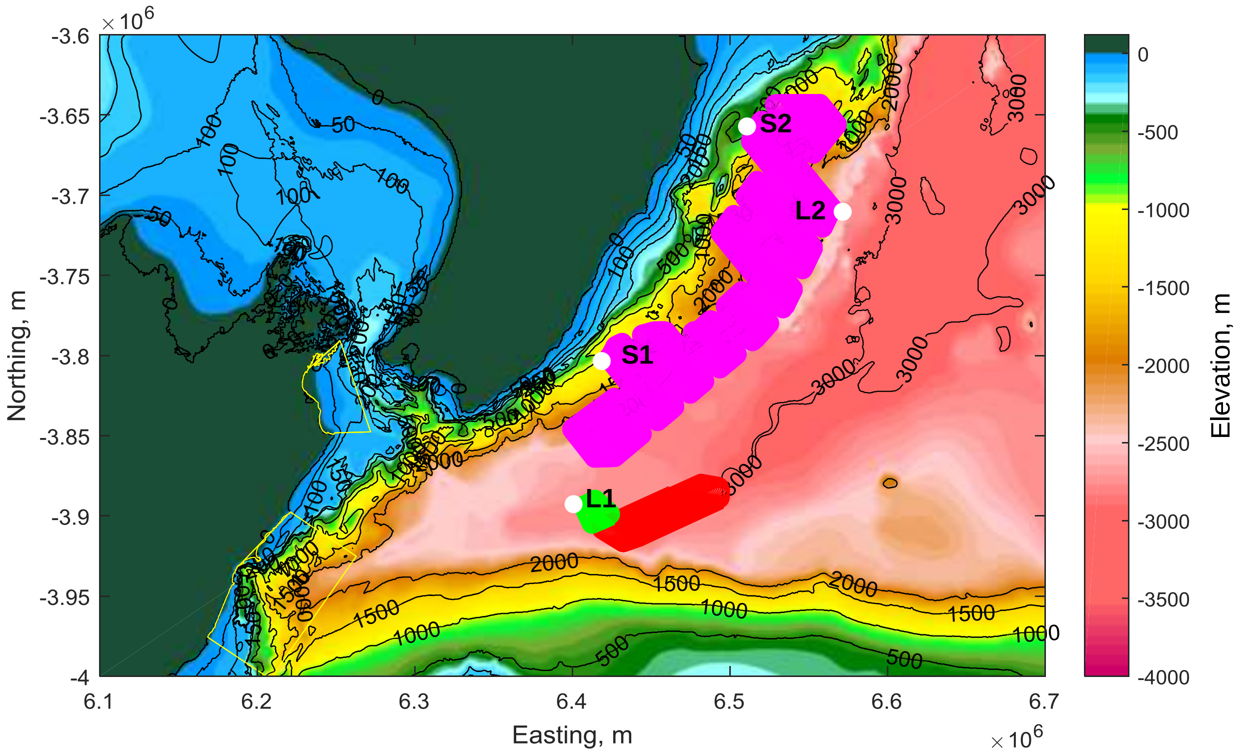
3.1.1 Bathymetry

The bathymetry data used for the sound propagation modelling were obtained from the National Institute of Water and Atmospheric Research (NIWA) NZ Region 250 m gridded bathymetric dataset (CANZ, 2008).

The corresponding bathymetric imagery around survey areas with a resolution of 250 m is presented in **Figure 6**.

The short-range modelling locations S1 and S2 were selected largely on the basis that these points represent the shallowest water depths north and south of the survey area near the coast. The long-range modelling location L1 was selected because of its proximity to the Clifford and Cloudy Bay Marine Mammal Sanctuary near Cook Strait, as well as the Kaikoura Whale Sanctuary, and the location L2 considers noise propagation exposure to the deep water regions to the northeast of the largest survey area.

Figure 6 **The bathymetric imagery in a resolution of 250 m covering the survey areas. The coordinate system is based on map projection WGS 84 / Mercator 41. Yellow polygons show the marine mammal sanctuaries and three survey areas with survey lines are of different colors (magenta, red and green). White dots indicate the selected source locations for the short range (S1 & S2) and long range (L1 & L2) modelling cases.**



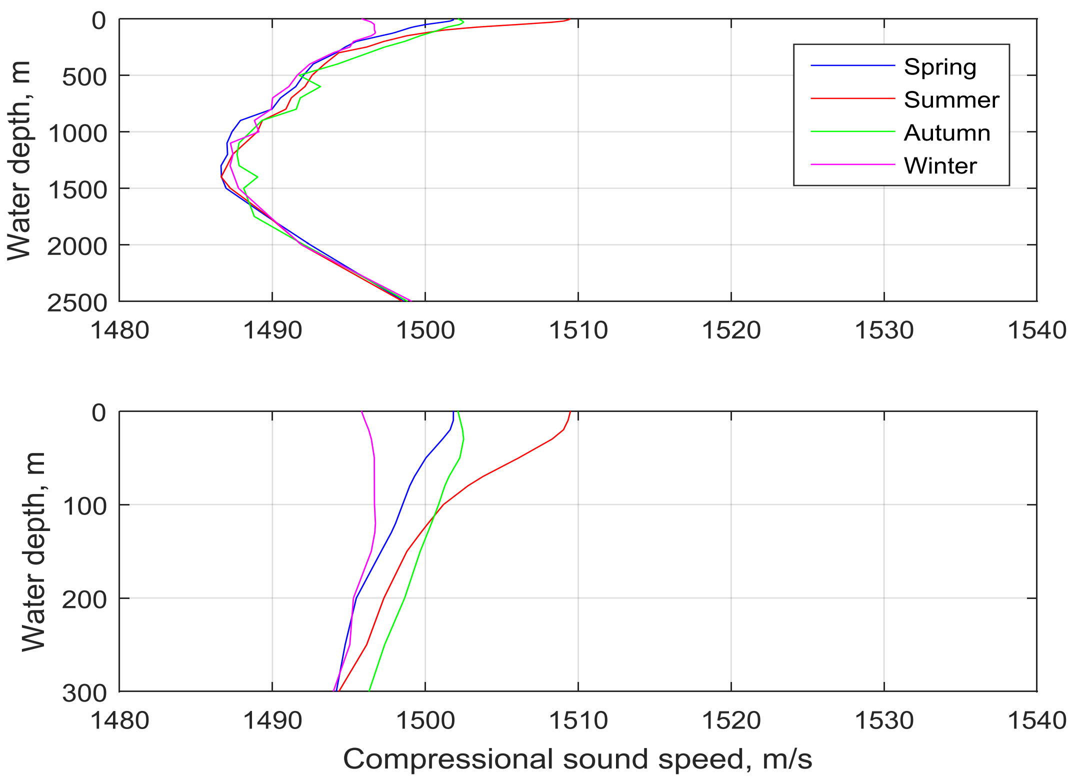
3.1.2 Sound speed profiles

Temperature and salinity data required to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (WOA09) (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure used to calculate the sound speed based on depth and latitude of each particular modelling location was obtained using Sanders and Fofonoff's formula (Sanders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

Figure 7 presents the typical sound speed profiles for four Southern Hemisphere seasons in close proximity to the survey areas within the Pegasus Basin. The figure demonstrates that the most significant distinctions for the profiles of four seasons occur within the mixed layer near the surface. The spring and summer seasons have downwardly refracting near-surface profiles, with the summer profile having the stronger downwardly refracting feature. Both the autumn and winter seasons exhibit a surface duct, with the profile in the winter season having a stronger and deeper surface duct than that in the autumn season. Due to the stronger surface duct within the profile, it is expected that the winter season will favour the propagation of sound from a near surface acoustic source array. In descending order, the autumn, spring and summer seasons are expected to have relatively weaker sound propagation for a near-surface acoustic source array.

The proposed SLB survey is scheduled to occur within the period from late November 2016 through to May 2017. Therefore, the autumn sound speed profile has been selected to provide the most conservative sound propagation modelling scenarios.

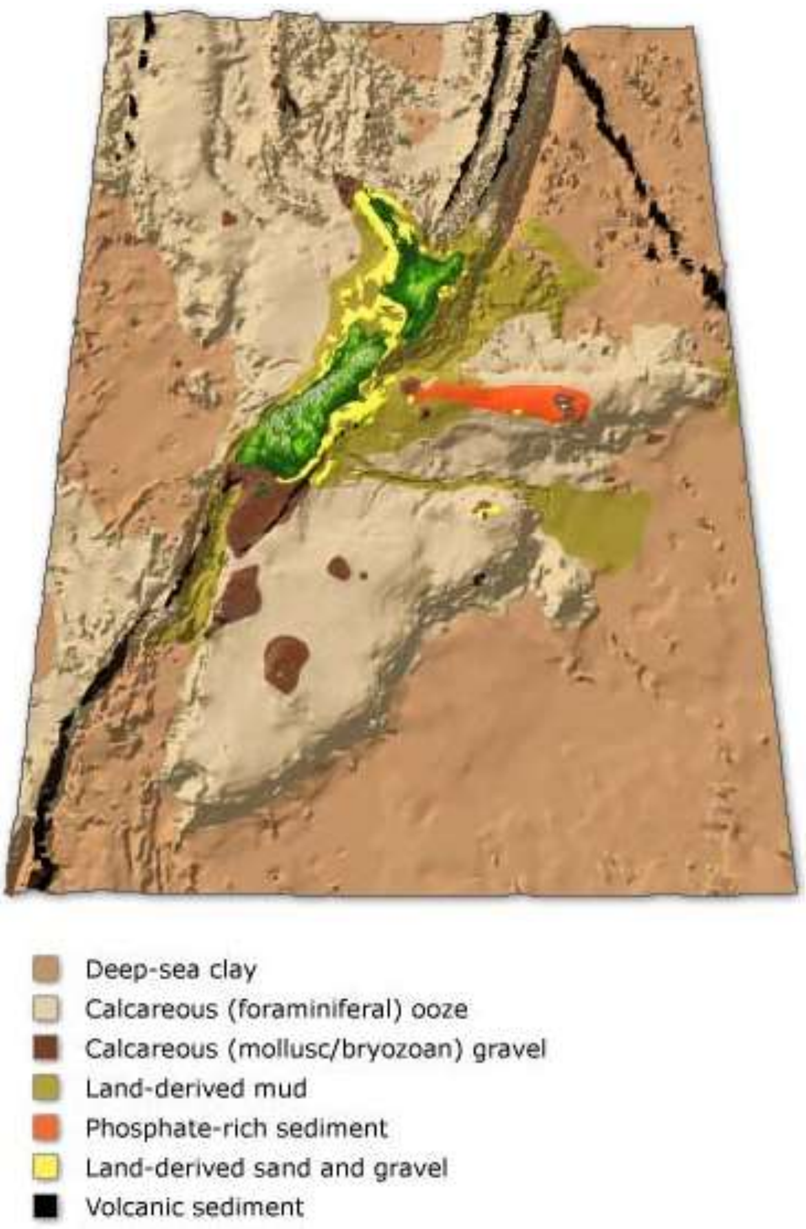
Figure 7 Typical sound speed profiles south of the North Island within Pegasus Basin for different Southern Hemisphere seasons. Top panel shows profiles in deep water region, bottom panel shows profiles in the continental shelf area.



3.1.3 Seafloor geo-acoustic models

New Zealand has diverse seafloor sediments thanks to its variable and dynamic marine and terrestrial environments. NIWA has produced a variety of marine sediment charts illustrating the ocean bottom types around coastal New Zealand and some offshore areas. The map in **Figure 8**Error! Reference source not found. extracted from NIWA illustrates the distribution of the main types of marine sediments found on the ocean floor around New Zealand (Lewis et al., 2012 & 2013).

Figure 8 The distribution of the main types of marine sediment on the seafloor within coastal and offshore regions around New Zealand



The Continental shelf is covered mainly with land-derived sand, gravel and mud sediment, except at the northern and southern extremities where the shelly sediment from once-living sea creatures prevails due to the lack of major rivers. Within the project area, off the southeast of the North Island within Pegasus Basin, land-derived mud with materials ranging from silt to clay forms the dominant seabed sediments.

The detailed sediment types for various relevant coastal and offshore regions are referred to in the NZ marine sediment charts and some technical reports (e.g. Matthew et al., (2014) and Galindo-Romero et al., (2014)). A summary of sediment types in and around the Pegasus Basin is provided in **Table 1**.

Table 1 Detailed sediment types within the coastal and offshore regions southeast of the North Island.

Region		Sediment Type
Southeast of the North Island	Continental Shelf and slope	Silt - clay
	Hikurangi Trough (Turbidite Plain)	Clay - mud
	Chatham Rise	Fine sand
	North Chatham Slope	Silt - clay

The geoacoustic properties for the various possible sediment types within the coastal and offshore regions around the North Island are presented in **Table 2**. The geoacoustic properties for sand, silt and clay are as described in Hamilton (1980), with attenuations referred to in Jensen et al., (2011). The elastic properties of sand, silt and clay are treated as negligible.

Table 2 Geoacoustic properties for various possible sediment types within the coastal and offshore regions around the North Island.

Sediment Type	Density, ρ, ($kg.m^{-3}$)	Compressional Wave Speed, c_p, ($m.s^{-1}$)	Compressional Wave attenuation, α_p, (dB/λ)
Sand			
Coarse Sand	2035	1835	0.8
Fine Sand	1940	1750	0.8
Very Fine Sand	1855	1700	0.8
Silt - Clay			
Silt	1740	1615	1.0
Sand-Silt-Clay	1595	1580	0.4
Clayey Silt	1490	1550	0.2
Silty Clay	1420	1520	0.2

The reflection coefficients for sediments of sand, silt and clay are presented in **Figure 9** and **Figure 10** respectively. As can be seen, the sandy seafloor sediments are more reflective than the silt and clay sediments, particularly at low grazing angles. For silty sediments, a seafloor of silt is overall more reflective than the rest of the silt/clay materials.

Figure 9 The reflection coefficients (magnitude - top panel and phase – bottom panel) for sand sediments (coarse sand, fine sand and very fine sand)

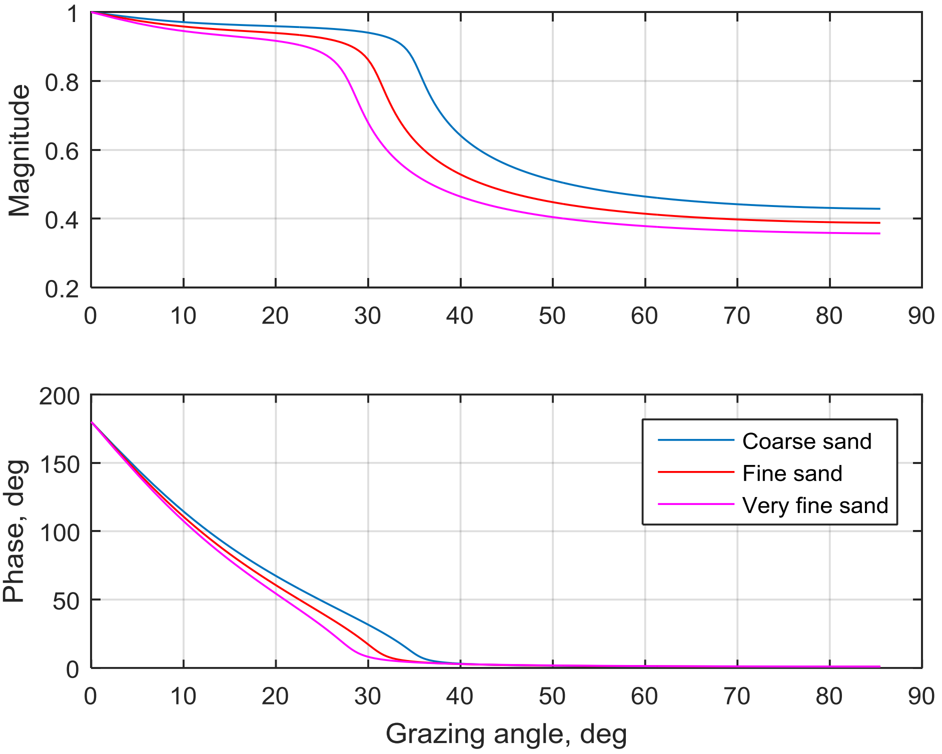
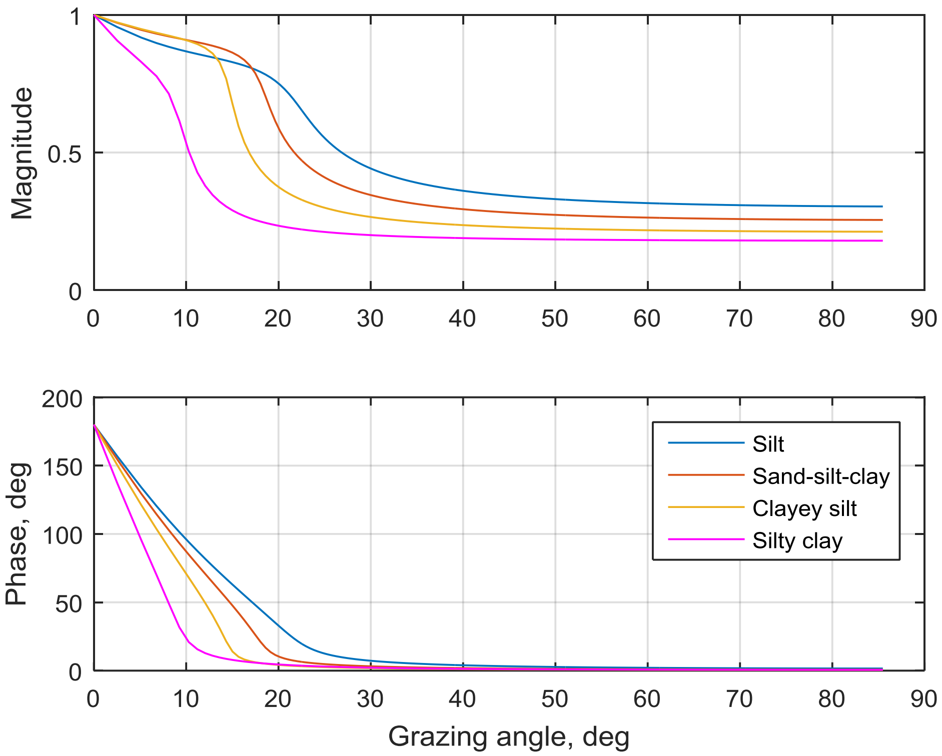


Figure 10 The reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay)



3.2 Detailed modelling methodologies and procedures

The considerations for the achievable modelling accuracy, source directivity characteristics and computational cost of the short range and long range modelling cases are different. The following sections describe the different modelling methodologies and procedures employed for the short range and long range modelling cases.

3.2.1 Short range modelling

3.2.1.1 Modelling methodology and procedure

The short range modelling is used to verify mitigation zones in relatively close proximity to the array source, and requires modelling predictions with high accuracy. In addition, interference between the signals arriving at any receiving location from different acoustic sources in the array is expected to be significant and complex for such a near-field scenario. To account for these considerations, the predictions for the short range case are modelled by adding or reconstructing the received signal waveforms from individual airgun source units within the array. The wavenumber integration modelling algorithm SCOOTER (Porter, 2010) is used to calculate the transfer functions (both amplitudes and phases) between sources and receivers. SCOOTER is a finite element code for computing acoustic fields in range-independent environments. The method is based on direct computation of the spectral integral, and is capable of dealing with an arbitrary layered seabed with both fluid and elastic characteristics.

The following procedure is followed to calculate received SELs:

1) The modelling algorithm SCOOTER is executed for frequencies from 1 Hz to 1 kHz, in a 1-Hz increment. The source depth of the Delta 3 broadband 5,085 cubic inch source array is 7.0 m. A 1-m receiver grid in both range and depth with a maximum range up to 4 km is applied for the selected water depth. For each 1-m gridded receiver, the received SEL is calculated by following steps 2) – 5);

2) The range from each acoustic source in the array to each receiver is calculated, and the transfer function between each acoustic source and the receiver is obtained by interpolation of the results produced by modelling algorithm SCOOTER in Step 1). This interpolation involves both amplitude and phase of the transfer function;

3) The complex frequency domain signal of the notional signature waveform for each acoustic source is calculated via Fourier Transform, and multiplied by the corresponding transfer function from Step 2) to obtain the frequency domain representation of the received signal from that particular acoustic source;

4) The waveform of the received signal from each acoustic source is reconstructed via Inverse Fourier Transform. The received signal waveforms from all acoustic sources in the array are summed to obtain the overall received signal waveform;

5) The overall signal waveform is squared and integrated to obtain the received SEL.

3.2.1.2 Modelling scenarios

Two source locations in both northern and southern parts of the survey area close to the coast were selected for the short range modelling. The two modelling locations were selected as they are the shallowest points in the northern and southern parts of the survey areas. These locations are shown in **Figure 6** with their details provided in **Table 3**.

For the purpose of the short range modelling, the worst case conditions for underwater noise propagation have been assumed, i.e. a silt seabed and autumn sound speed profiles for the two locations.

Table 3 Details of the two selected source locations for the short range modelling. The coordinate system is based on map projection WGS 84 / Mercator 41.

Source Location	Water Depth, m	Coordinates [Easting, Northing], m	Locality
S1	900	[6.4229 x 10^6, - 3.7932 x 10^6]	The shallowest point south of the survey area
S2	400	[6.5130 x 10^6, - 3.6539 x 10^6]	The shallowest point north of the survey area

3.2.2 Long range modelling

3.2.2.1 Modelling methodology and procedure

The long range modelling case can achieve reasonable accuracy of prediction considering that it generally involves complex and variable environmental factors such as sound speed profiles and bathymetric variations. Therefore, the modelling prediction for the long range case is carried out using the far-field source levels of octave frequency bands and their corresponding transmission loss calculations.

The fluid parabolic equation (PE) modelling algorithm RAMGeo (Collins, 1993) is used to calculate the transmission loss between the source and the receiver. RAMGeo is an efficient and reliable PE algorithm for solving range-dependent acoustic problems with fluid seabed geoacoustic properties.

The received SEL's are calculated following the procedure outlined below:

1) One-third octave source levels for each azimuth to be considered are obtained by integrating the horizontal plane source spectrum over each frequency band, and these levels are then corrected to SEL levels;

2) Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 8 Hz to 1 kHz, with a maximum range of 200 km and at 5 degree azimuth increments. The bathymetry variation along each modelling track is obtained via interpolation from the CANZ (2008) dataset;

3) The one-third octave source SEL levels and transmission loss are combined to obtain the received SEL levels as a function of range, depth and frequency; and

4) The overall received SEL levels are calculated by summing all frequency band SEL levels.

3.2.2.2 Modelling scenarios

Two source locations (L1 and L2 as shown in **Figure 6**) were selected for the long range modelling, with details of the selected source locations listed in **Table 4**.

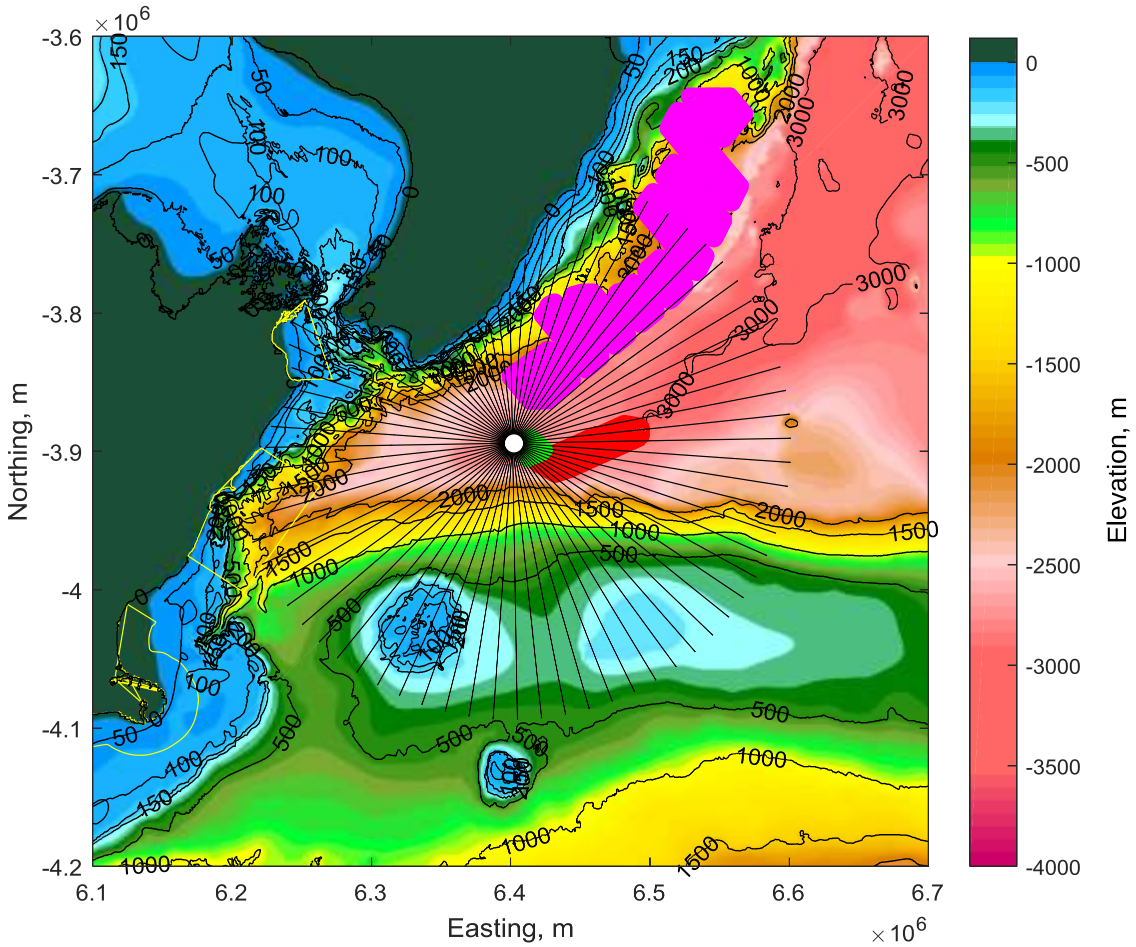
The seasonal sound speed profile, along with the silt seafloor geoacoustic model (i.e. the predominant sediment type along the long range propagation path from the source location to the coastal marine mammal sanctuaries and near shore noise sensitive areas) have been used for the long range modelling as a worst case scenario.

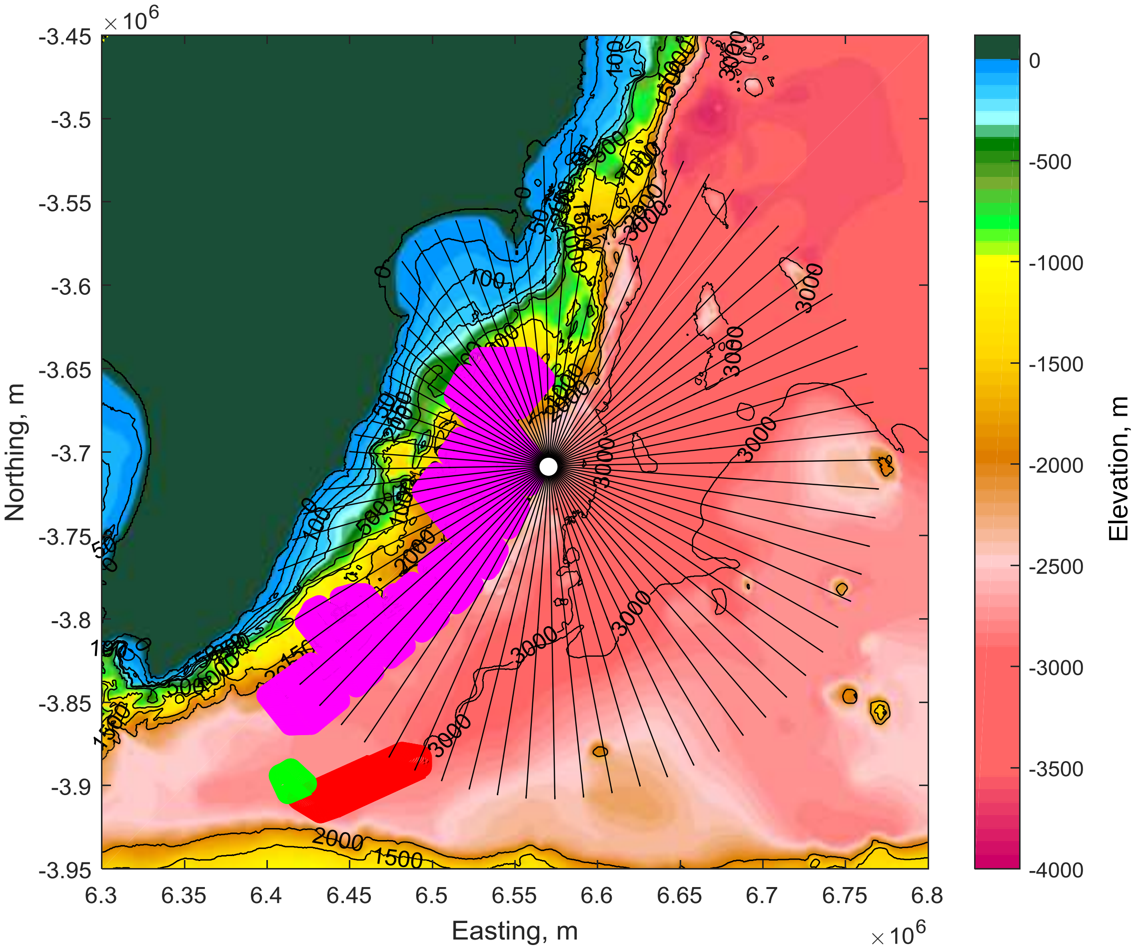
The survey orientations for each survey area were calculated based on the survey line data provided by SLB. The characteristics of the two source locations are detailed in **Table 4**.

Table 4 Details of the selected two source locations for the long range modelling. The coordinate system is based on map projection WGS 84 / Mercator 41.

Source Location	Water Depth, m	Coordinates [Easting, Northing]	Survey Orientation, degree	Locality
L1	2,730	[6.4014 x 10^6, - 3.8940 x 10^6]	**51**, clockwise from the eastern direction	Close to the Clifford and Cloudy Bay Marine Mammal Sanctuary, and Kaikoura Whale Sanctuary
L2	2,750	[6.5706 x 10^6, - 3.7082 x 10^6]	**24**, anti-clockwise from the eastern direction	At the outer boundary of the survey area with noise propagation exposure to the deep water regions to the east and north

Figure 11 Long range modelling source locations L1 (top) and L2 (bottom), with modelling sound propagation paths (black lines) overlaying local bathymetry. The coordinate system is based on map projection WGS 84 / Mercator 41.





Northing, m
Easting, m
Elevation, m
×10^6
-3.45
-3.5
-3.55
-3.6
-3.65
-3.7
-3.75
-3.8
-3.85
-3.9
-3.95
6.3
6.35
6.4
6.45
6.5
6.55
6.6
6.65
6.7
6.75
6.8
0
-500
-1000
-1500
-2000
-2500
-3000
-3500
-4000

4 RESULTS

4.1.1 Short range modelling

The received SEL levels from the Delta 3 broadband 5,085 cubic inch array for the two source modelling locations (S1 and S2) with the autumn season sound speed profile and the corresponding silt seabed have been calculated. The maximum received SELs across the water column for the two modelling source locations are presented as a function of azimuth and range from the centre of the array in **Figure 12**. Both figures illustrate that the source array has weak directivities in both the in-line and cross-line directions.

The scatter plots of the predicted maximum SELs across the water column from the source array for all azimuths are displayed in **Figure 13** for the two source locations. This data is presented as a function of range from the centre of the source array, and is illustrated together with the mitigation threshold levels (i.e. 186 dB and 171dB re 1µPa^2·S) and mitigation ranges (i.e. 200 m, 1.0 km and 1.5 km).

For the two source locations the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.0 km.

The predictions of the maximum SELs received at the three mitigation ranges for the two short range modelling locations are listed in **Table 5**. **Table 6** presents the ranges from the centre of the source array to where the predicted maximum SELs meet the threshold levels (186 dB and 171 dB re 1µPa^2·s) for the two modelling scenarios.

Table 5 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the Delta 3 broadband 5,085 cubic inch array for the two source locations S1 and S2.

Source location	Water depth, m	Seafloor	SEL at different ranges, dB re 1µPa^2·s		
			200 m	**1.0 km**	**1.5 km**
S1	900	Silt	183.2	166.7	162.1
S2	400		183.2	167.6	164.2

Table 6 Ranges from the center of the Delta 3 broadband 5,085 cubic inch array where the predicted maximum SELs for all azimuths equal the SEL threshold levels for the two source locations S1 and S2.

Source location	Water depth, m	Seafloor	Ranges complying with the following SEL thresholds, m	
			SEL < 186 dB re 1µPa^2·s	**SEL < 171 dB re 1µPa^2·s**
S1	900	Silt	140 m	700 m
S2	400		145 m	720 m

Figure 12 The predicted maximum received SELs across the water column from the Delta 3 broadband 5,085 cubic inch array as a function of azimuth and range from the centre of the array, for source location S1 (top) and S2 (bottom). 0 degree azimuth corresponds to the in-line direction. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

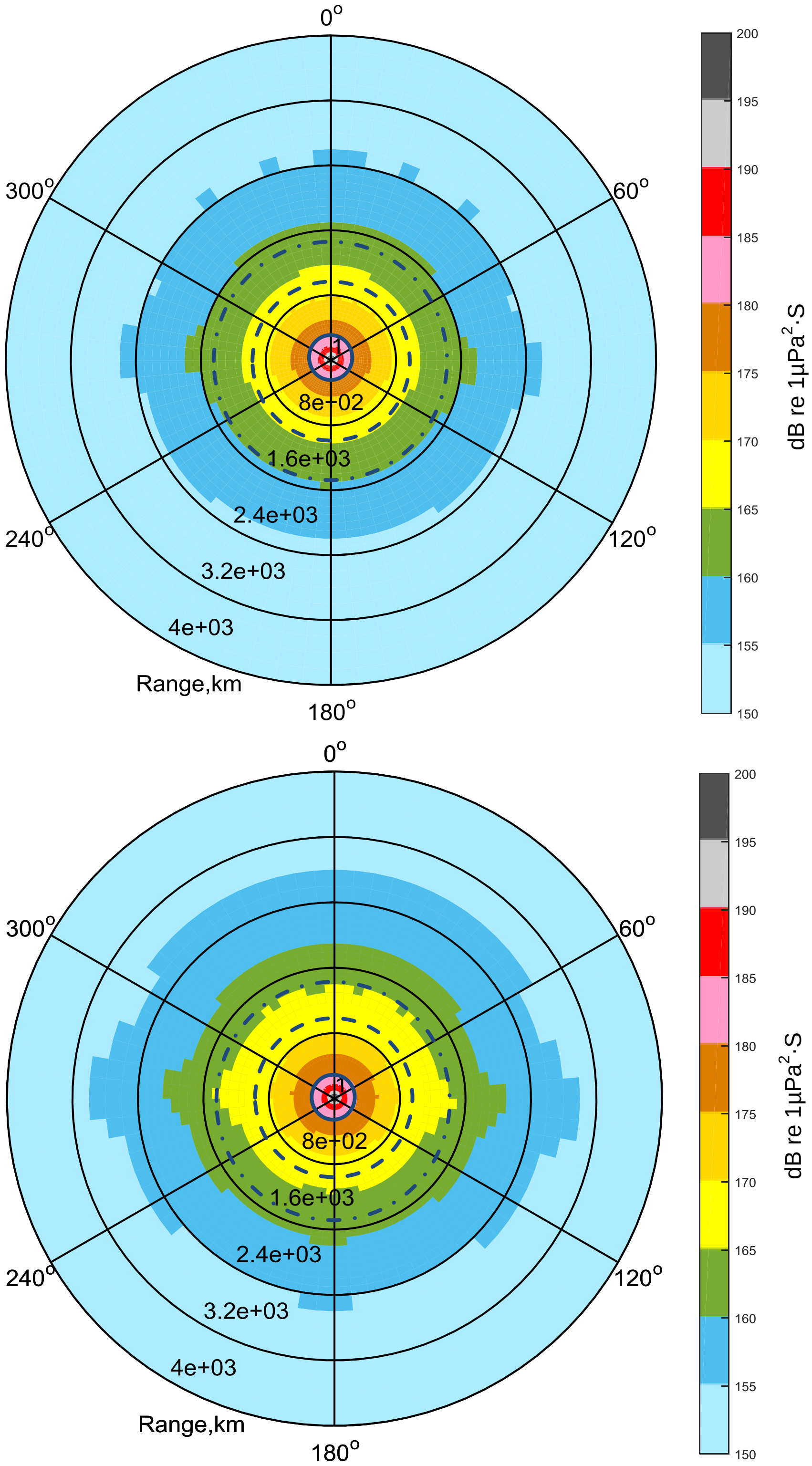
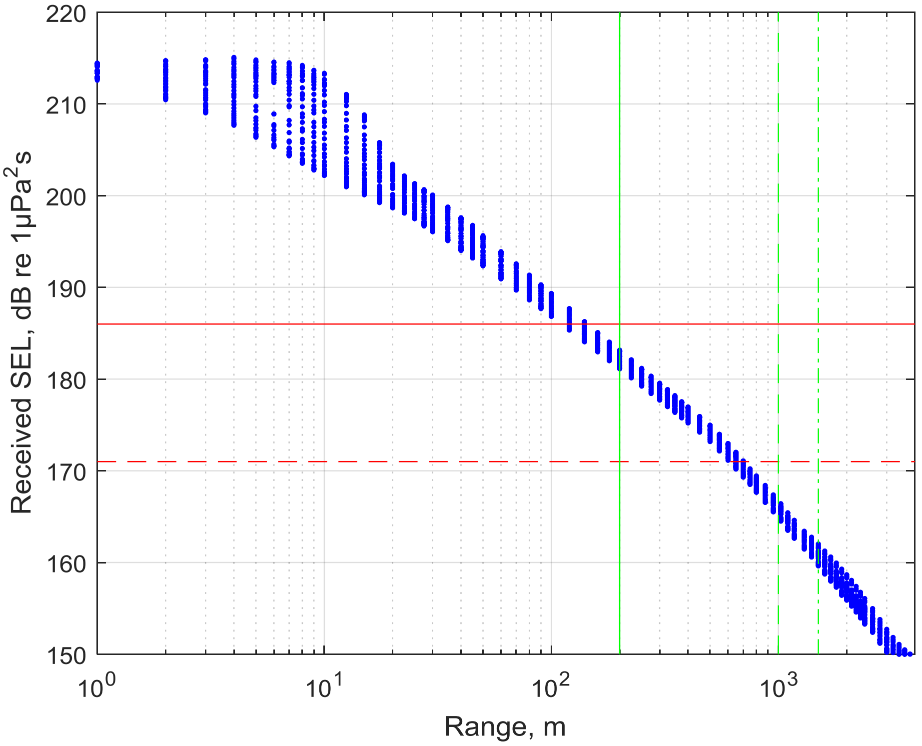
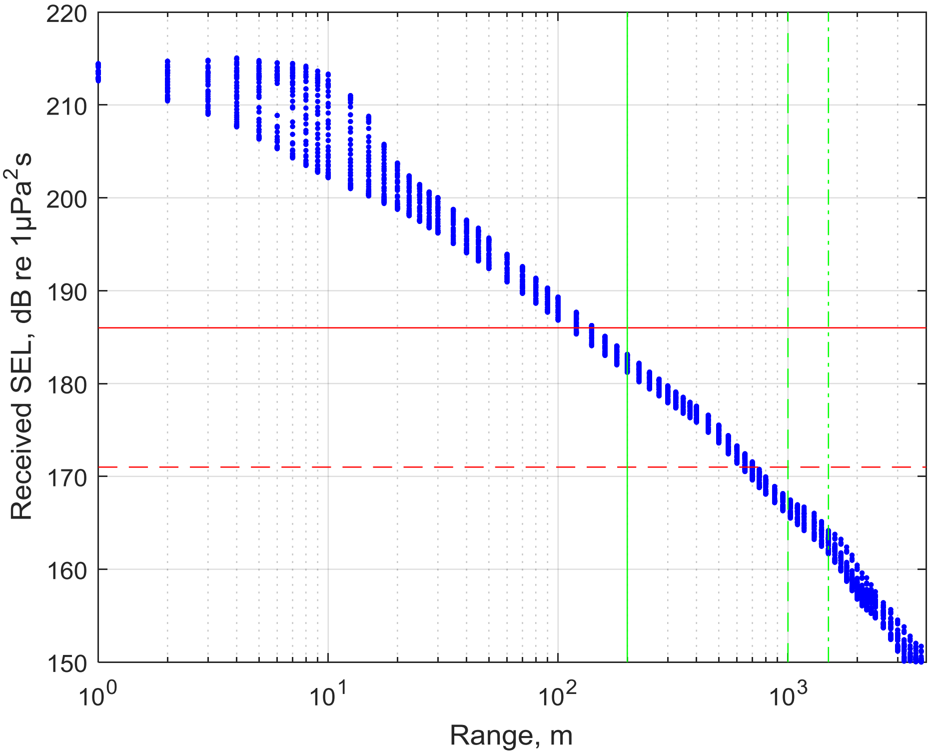


Figure 13 Scatter plots of predicted maximum SELs across the water column from the Delta 3 broadband 5,085 cubic inch array for all azimuths as a function of range from the center of the source array, for source location S1 (top) and S2 (bottom). Horizontal red lines show mitigation thresholds of 186 dB re 1µPa^2·S (solid) and 171dB re 1µPa^2·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).





4.1.2 Long range modelling

Figure 14 and **Figure 15** show the contour images of the predicted maximum SELs received at locations up to 200 km from the two long range source locations L1 and L2 respectively, overlaying the local bathymetry contours. As can be seen from the two figures, the received noise levels at far-field locations vary at different angles and distances from the source locations. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations.

Figure 16 to **Figure 19** present the modelled SELs across range and depth along the cross-line and in-line directions for the source location L1. **Figure 20** to **Figure 23** present the modelled SELs across range and depth along the cross-line and in-line directions for the source location L2.

Figure 14 Modelled maximum SEL (maximum level at any depth) contour for source location L1 to a maximum range of 200 km, overlaying with bathymetry contour lines.

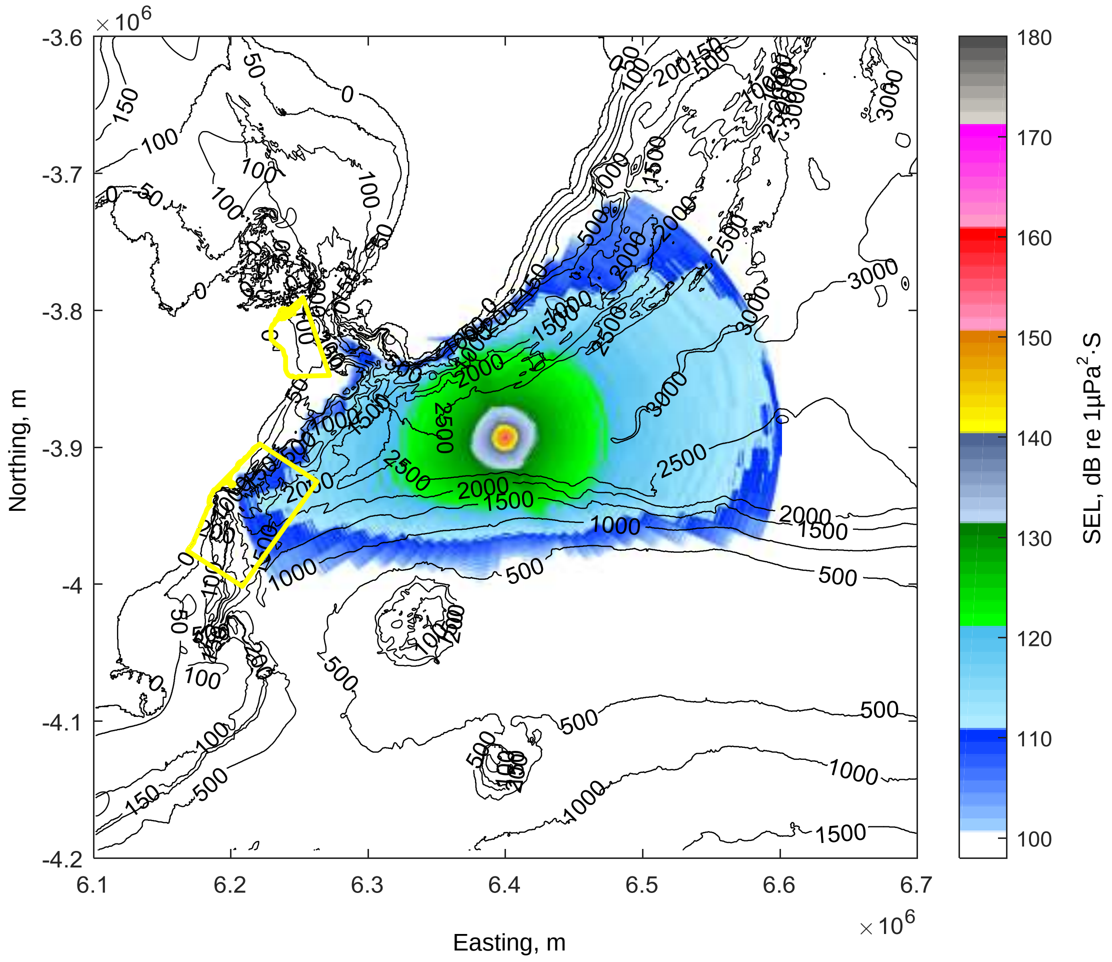
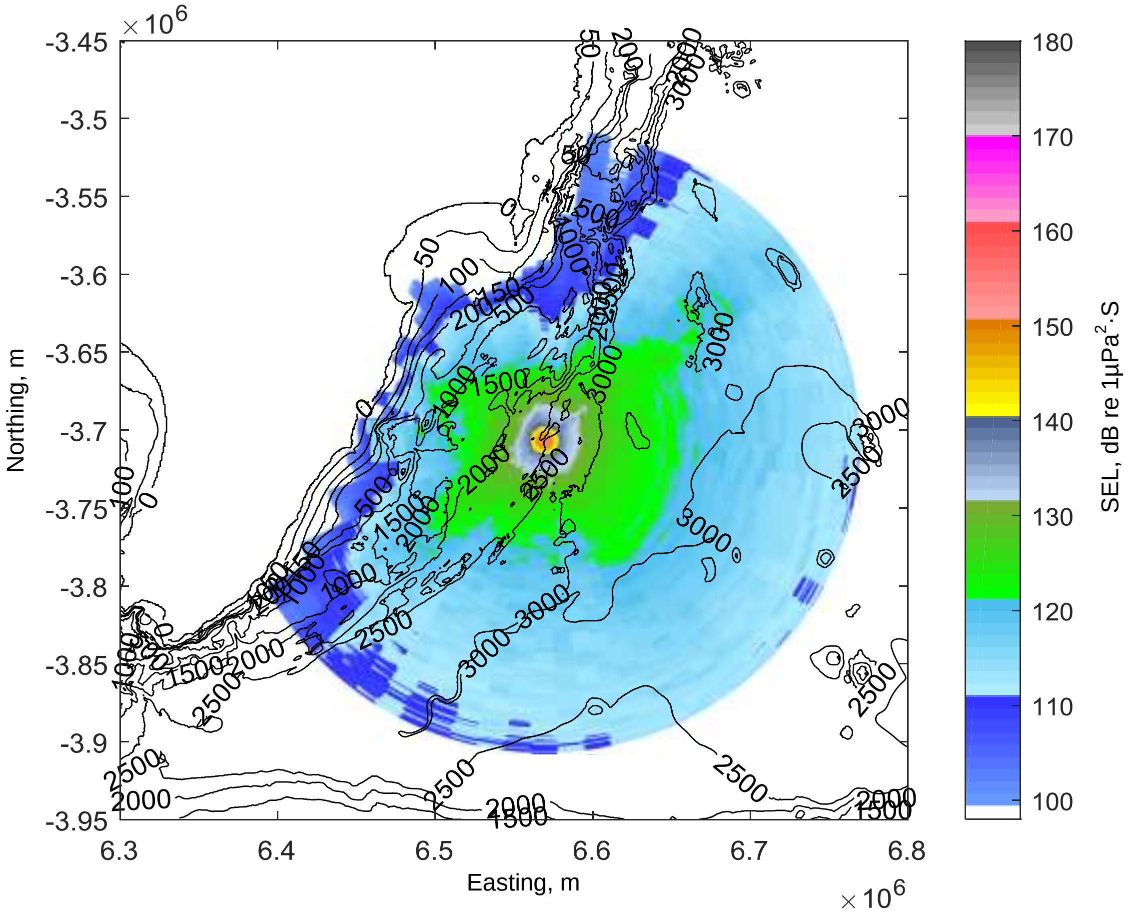


Figure 15 Modelled maximum SEL (maximum level at any depth) contour for source location L2 to a maximum range of 200 km, overlaying with bathymetry contour lines



For both source locations, significantly higher noise attenuations are predicted for the propagation paths with upslope bathymetry profiles, particularly for the directions towards the continental slope sections, due to the stronger interaction between the sound signal and the seabed, coupled with the lower reflection coefficient at higher grazing angles for the silty seabed. The paths towards deep water tend to favour noise propagation, with received noise levels predicted to be up to 110 dB re 1μPa^2·S at a distance of 200 km from the two source locations in this direction.

The received noise levels within the Clifford and Cloudy Bay Marine Mammal Sanctuary from the source location L1 are predicted to be below 100 dB re 1μPa^2·S. For the Kaikoura Whale Sanctuary, the received noise levels are predicted to be up to 115 dB re 1μPa^2·S.

At the nearest 12 nautical mile offshore boundary to the two source locations, the received noise levels are predicted to be up to 120 dB re 1μPa^2·S for source location L1 and 110 dB re 1μPa^2·S for source location L2.

Figure 16 Modelled SELs vs range and depth along the propagation path towards northeast cross-line direction from the source location L1. Black line shows the seabed depth variation.

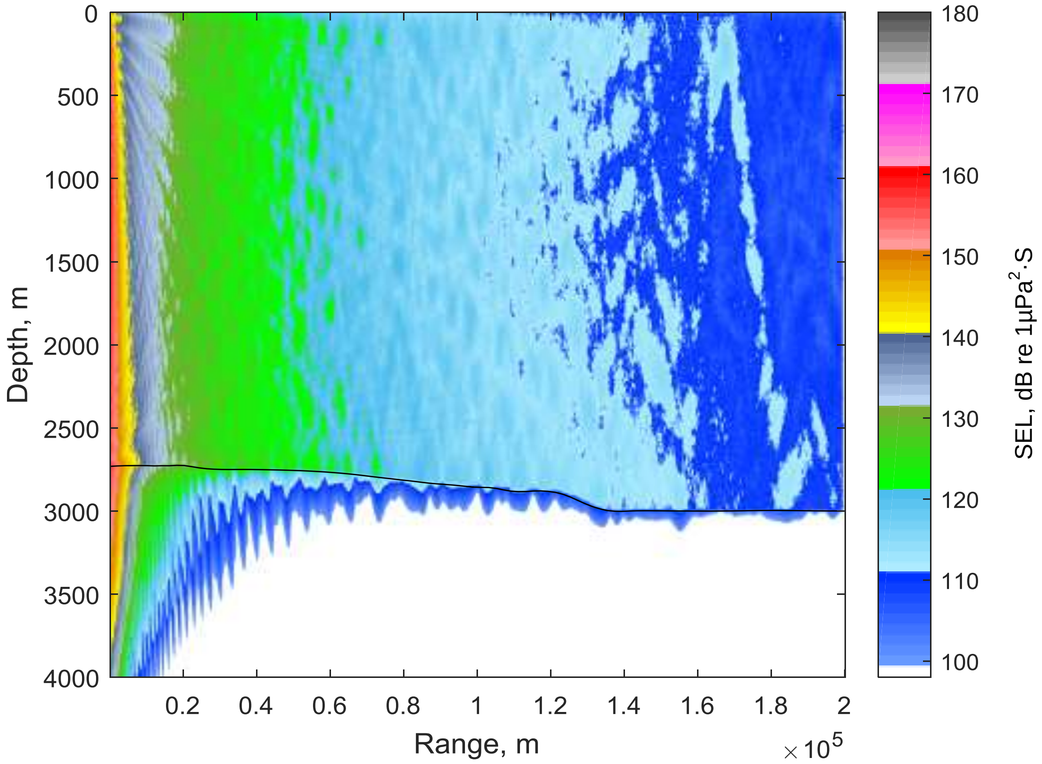


Figure 17 Modelled SELs vs range and depth along the propagation path towards southwest cross-line direction from the source location L1. Black line shows the seabed depth variation.

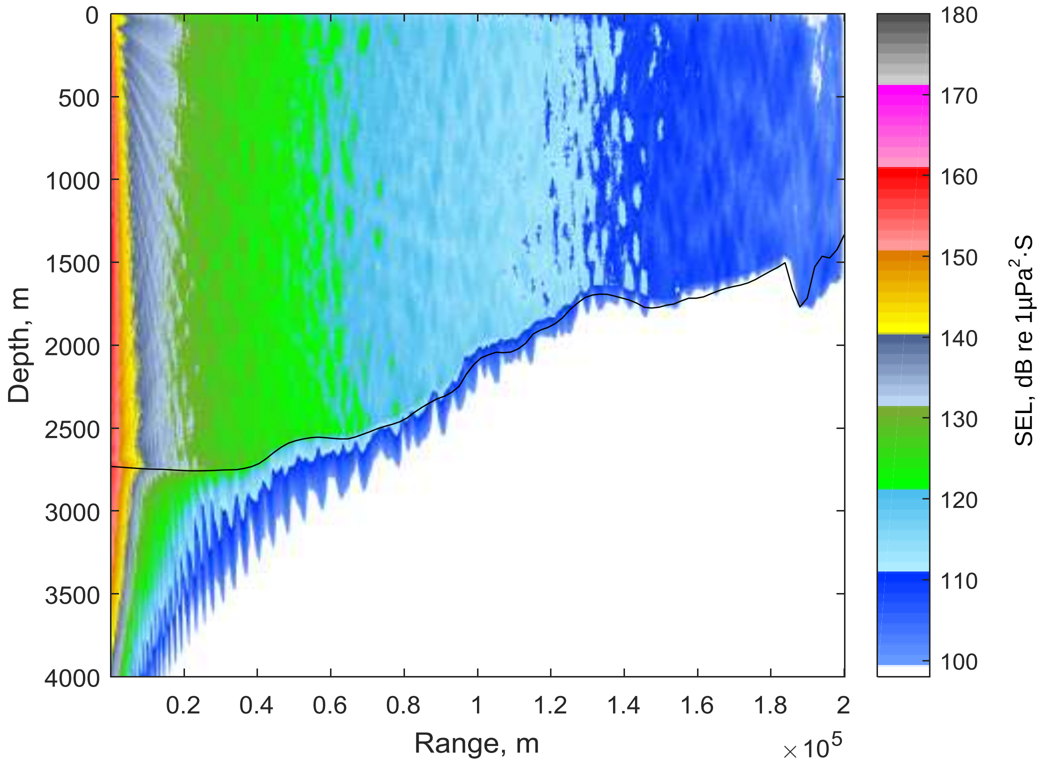


Figure 18 Modelled SELs vs range and depth along the propagation path towards southeast in-line direction from the source location L1. Black line shows the seabed depth variation.

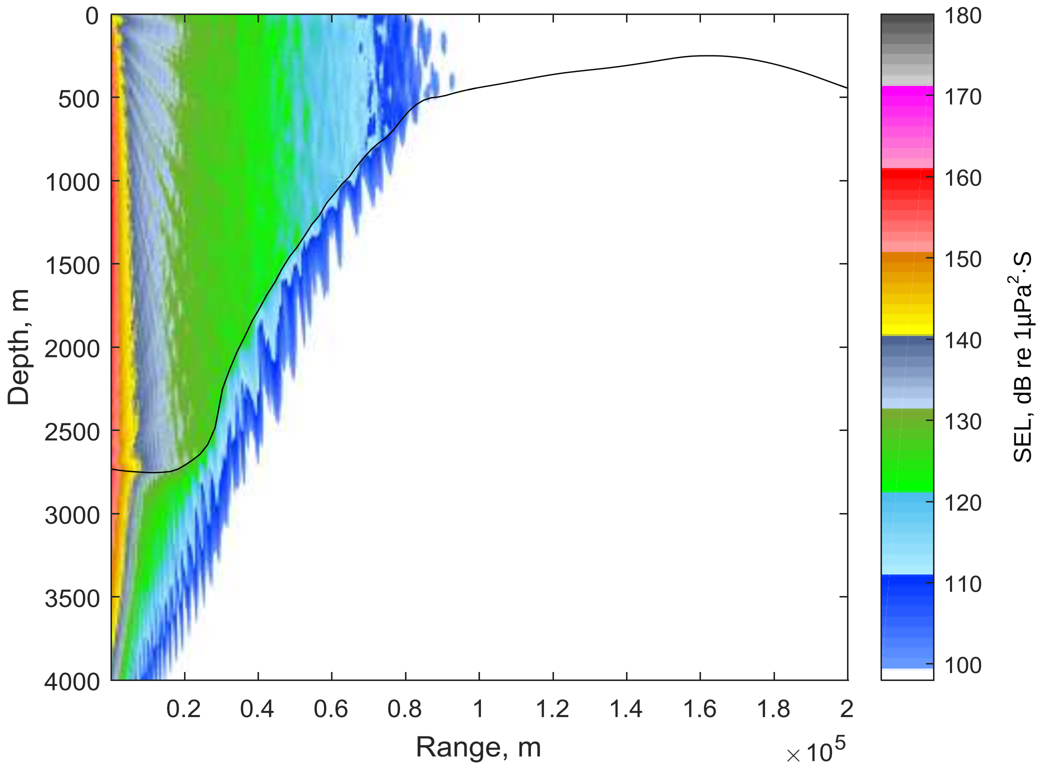


Figure 19 Modelled SELs vs range and depth along the propagation path towards northwest in-line direction from the source location L1. Black line shows the seabed depth variation.

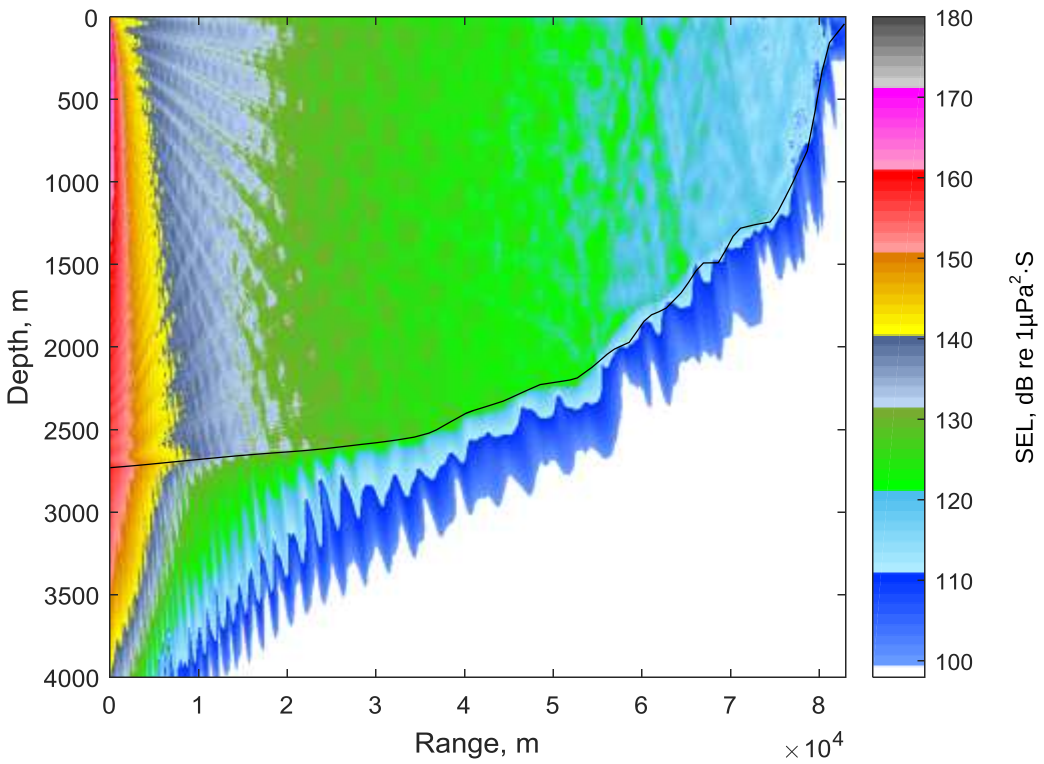


Figure 20 Modelled SELs vs range and depth along the propagation path towards southeast cross-line direction from the source location L2. Black line shows the seabed depth variation.

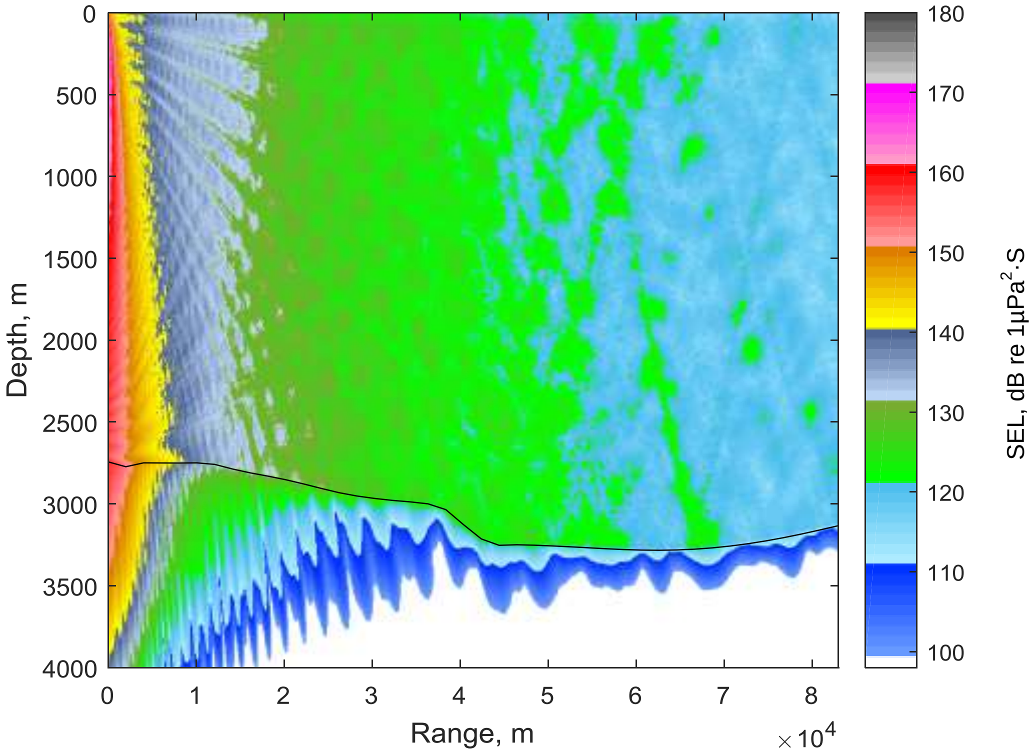


Figure 21 Modelled SELs vs range and depth along the propagation path towards northwest cross-line direction from the source location L2. Black line shows the seabed depth variation.

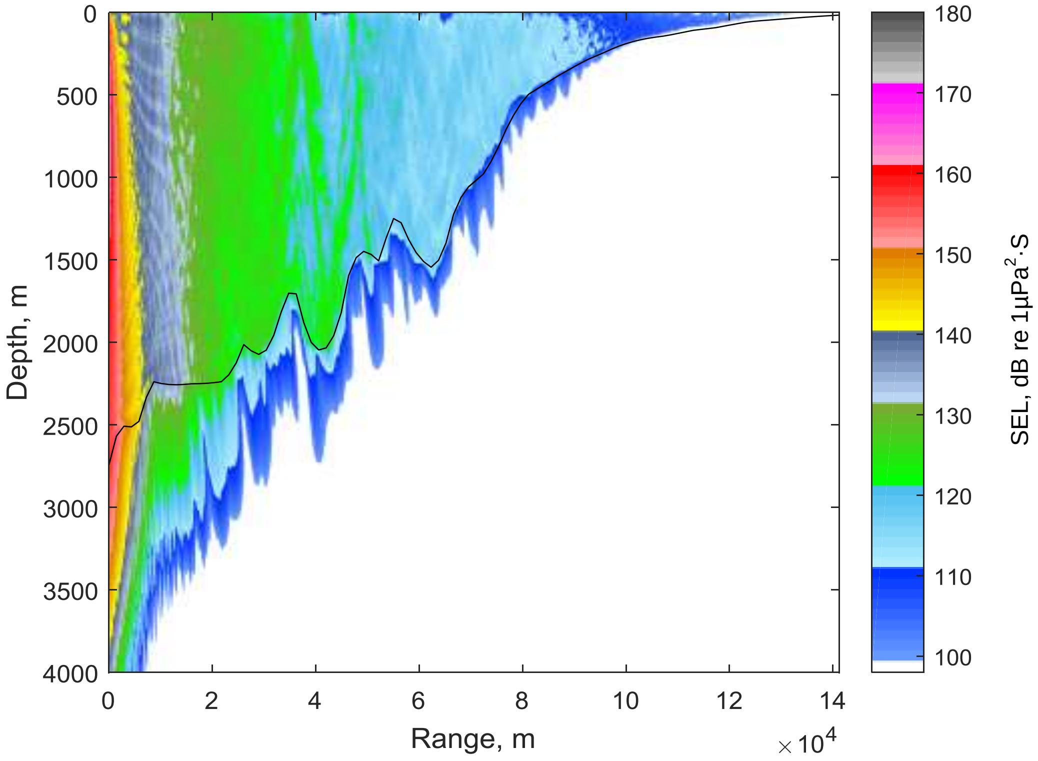


Figure 22 Modelled SELs vs range and depth along the propagation path towards southwest in-line direction from the source location L2. Black line shows the seabed depth variation.

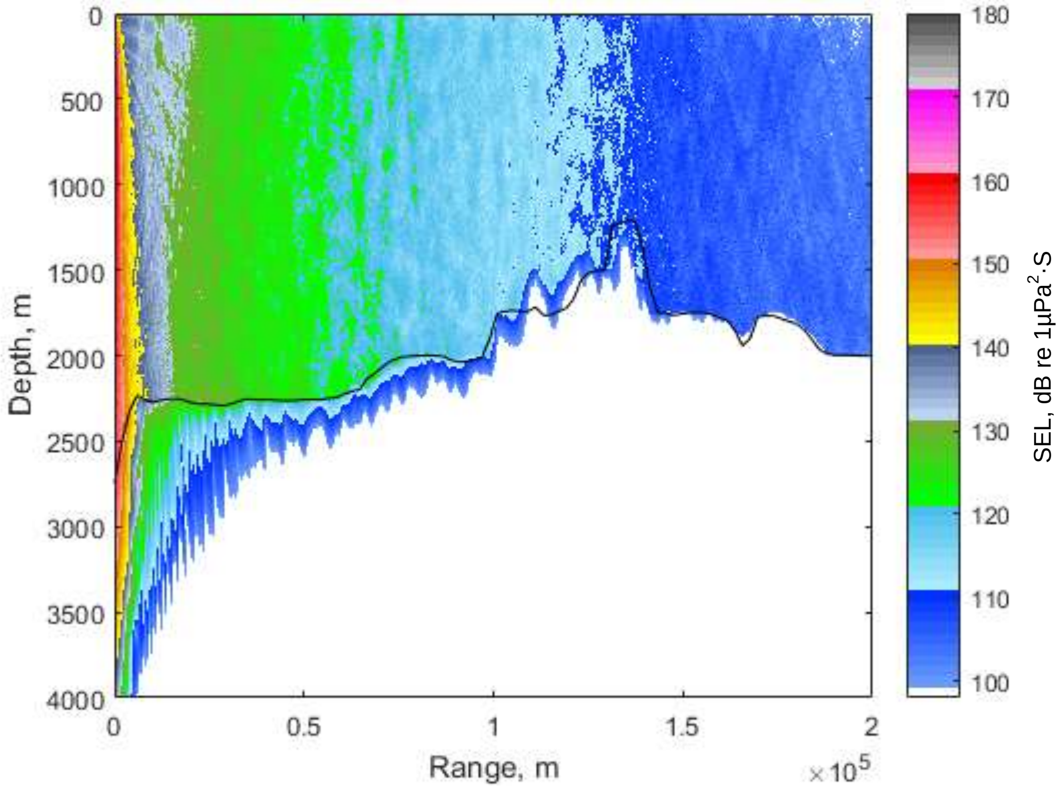
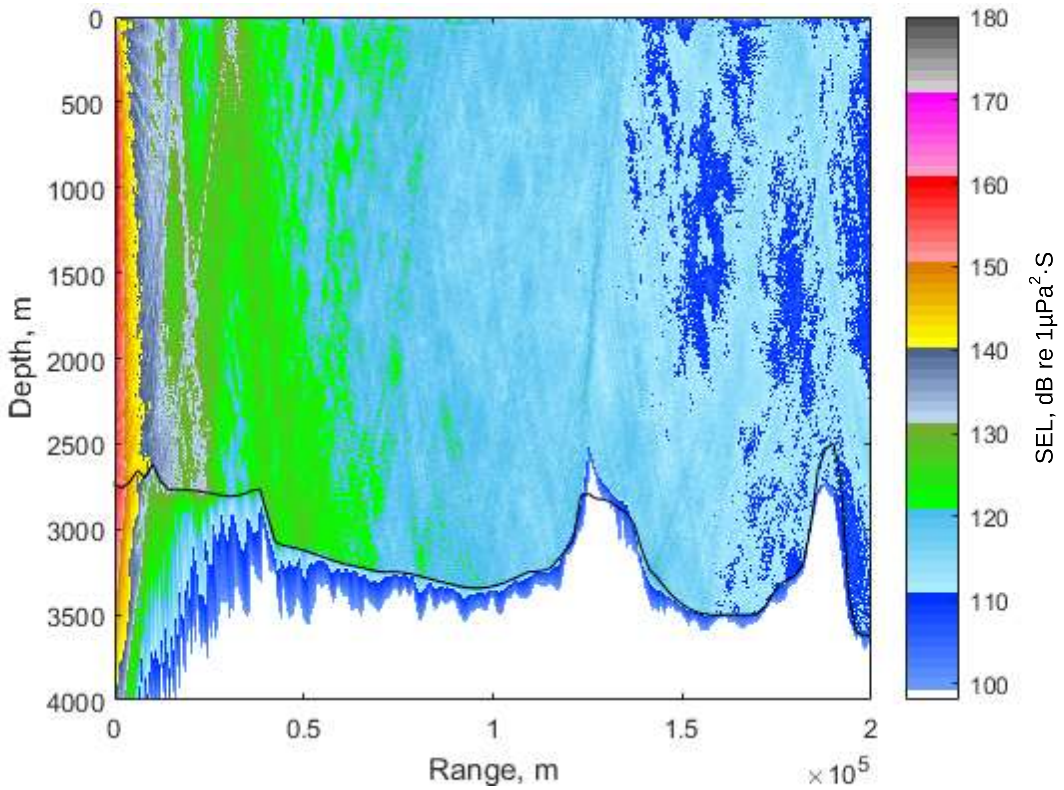


Figure 23 Modelled SELs vs range and depth along the propagation path towards northeast in-line direction from the source location L2. Black line shows the seabed depth variation.



5 CONCLUSIONS

SLB proposes to undertake a 3D marine seismic survey in the Pegasus Basin from November 2016 through to May 2017. This report details the STLM study that has been carried out for the proposed survey, which includes three modelling components - array source modelling, short range modelling and long range modelling.

The acoustic source array configuration that will be used for the Pegasus Basin Seismic Survey is the Delta 3 broadband 5,085 cubic inch array. The array source modelling illustrates distinctive array directivity of angle and frequency dependence for the energy radiation from the array, as a result of interference between signals from different array elements, particularly the three sub-arrays.

The short range modelling predictions using worst case modelling conditions (i.e. the seasonal sound speed profile of autumn and a silt seabed) demonstrate that the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.0 km for the two selected short-range modelling source locations. Although the volume of the seismic source array is comparatively large, the deep water within the survey area (minimum 400 m) and relatively weak directivities of the source array result in energy emissions from the source dissipating more evenly over the water column and azimuths.

The long range modelling shows that the received SELs vary at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and particularly the propagation effects caused by bathymetry and sound speed profile variations.

The received noise levels within the Clifford and Cloudy Bay Marine Mammal Sanctuary from the relevant long range source location are predicted to be below 100 dB re 1µPa^2·S. For the Kaikoura Whale Sanctuary, the received noise levels are predicted to be up to 115 dB re 1µPa^2·S. At the nearest 12 nautical mile offshore boundary to each of the long range source locations, the received noise levels are predicted to be up to 110 dB - 120 dB re 1µPa^2·S.

6 REFERENCES

Antonov, J. I., Seidov, D., Boyer, T. P., Locarnini, R. A., Mishonov, A. V., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, *World Ocean Atlas 2009, Volume 2: Salinity.* S. Levitus, Ed. NOAA Atlas NESDIS 69, U.S. Government Printing Office, Washington, D.C., 184 pp.

CANZ, 2008, New Zealand Region Bathymetry, 1:4 000 000, 2nd Edition, *NIWA Chart*, Miscellaneous Series No. 85.

Collins, M. D., 1993, A split-step Padé solution for the parabolic equation method, *J. Acoust. Soc. Am.*, 93: 1736-1742.

Del Grosso, V. A., 1974, New equation for the speed of sound in natural waters (with comparisons to other equations), *J. Acoust. Soc. Am*. 56: 1084-1091.

Dragoset, W. H., 1984, A comprehensive method for evaluating the design of airguns and airgun arrays, *16th Annual Proc. Offshore Tech. Conf*. 3: 75-84.

Galindo-Romero, M. and Duncan A., 2014, Received underwater sound level modelling for the Vulcan 3D seismic survey, *Project CMST 1323*, Centre for Marine Science and Technology, Curtin University.

Gundalf Designer, Revision AIR8.1f, 01 May 2015, Oakwood Computing Associates Limited. (https://www.gundalf.com/).

Hamilton, E. L., 1980, Geoacoustic modelling of the sea floor, *J. Acoust. Soc. Am*. 68: 1313:1340.

Jensen, F. B., Kuperman, W. A., Porter, M. B. and Schmidt, H., 2011, *Computational Ocean Acoustics*, Springer-Verlag New York.

Koessler, M. and Duncan, A., 2014, Received underwater sound level modelling for the Northwest Frontier seismic survey, New Zealand, *Project CMST 1329,* Centre for Marine Science and Technology, Curtin University.

Laws, R. M., Parkes, G. E., and Hatton, L., 1988, Energy-interaction: The long-range interaction of seismic sources, *Geophysical Prospecting*, 36: 333-348.

Laws, M., Hatton, L. and Haartsen, M., 1990, Computer Modelling of Clustered Airguns, *First Break*, 8(9): 331-338.

Lewis, K., Scott D. N., and Carter L., Sea floor geology - New Zealand sea-floor sediment, *Te Ara - the Encyclopedia of New Zealand*, updated 13 July 2012, URL: http://www.TeAra.govt.nz/en/sea-floor-geology/page-7.

Lewis, K., Scott D. N., and Carter L., Sea floor geology - How sediment forms, *Te Ara - the Encyclopedia of New Zealand*, updated 03 September, 2013, URL: http://www.TeAra.govt.nz/en/map/5615/new-zealands-marine-sediment.

Locarnini, R. A., Mishonov, A. V., Antonov, J. I., Boyer, T. P., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, *World Ocean Atlas 2009, Volume 1: Temperature.* S. Levitus, Ed. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 184 pp.

Parkes, G. E., Ziolkowski, A. M., Hatton L. and Haugland T., 1984, The signature of an airgun array: computation from near-field measurements – practical considerations, *Geophysics*, 49: 105-111.

Porter, M., 2010, Acoustics Toolbox in *Ocean Acoustics Library* (http://oalib.hlsresearch.com/).

Saunders, P. M. and Fofonoff, N. P., 1976, Conversion of pressure to depth in the ocean, *Deep-Sea Res*. 23: 109-111.

Vaage, S., Strandness, S. and Utheim, T., 1984, Signatures from single airguns, Geophysical Prospecting, 31: 87-97.

Ziolkowski, A. M., Parkes, G. E., Hatton, L. and Haugland, T., 1982, The signature of an airgun array: computation from near-field measurements including interactions, *Geophysics,* 47: 1413-1421.

Ziolkowski, A. M., 1970, A method for calculating the output pressure waveform from an airgun, *Geophys.J.R.Astr.Soc*., 21: 137-161.

ACOUSTIC TERMINOLOGY

Sound Pressure	A deviation from the ambient hydrostatic pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to reference pressure. The reference pressure underwater is P_{ref} = 1 µPa
Root-Mean-Square Sound Pressure Level (RMS SPL)	The mean-square sound pressure is the average of the squared pressure over some duration. The root-mean-square sound pressure level is the level of the root of the mean-square pressure against the reference pressure
Sound Exposure Level (SEL)	SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period
Power Spectral Density (PSD)	PSD describes how the power of a signal is distributed with frequency.
Source Level (SL)	The acoustic source level is the level referenced to a distance of 1m from a point source
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide.
Sound Speed Profile	A graph of the speed of sound in the water column as a function of depth

Ngai Tahu Taonga Species

	Maori Name	English Name	Scientific Name
Seabirds and shorebirds	Hoiho	Yellow-eyed penguin	*Megadyptes antipodes*
	Kakī	Black stilt	*Himantopus novaezelandiae*
	Karoro	Black-backed gull	*Larus dominicanus*
	Kōau	Black shag	*Phalacrocorax carbo*
	Kōau	Pied shag	*P. varius varius*
	Kōau	Little shag	*P. melanoleucos brevirostris*
	Kororā	Blue penguin	*Eudyptula minor*
	Kōtare	Kingfisher	*Halcyon sancta*
	Kōtuku	White heron	*Egretta alba*
	Kūaka	Bar-tailed godwit	*Limosa lapponica*
	Matuku moana	Reef heron	*Egretta sacra*
	Poaka	Pied stilt	*Himantopus himantopus*
	Pokotiwha	Snares crested penguin	*Eudyptes robustus*
	Tara	Terns	*Sterna spp*
	Tawaki	Fiordland crested penguin	*Eudyptes pachyrhynchus*
	Tītī	Sooty shearwater, Hutton's shearwater, Common diving petrel, South Georgian diving petrel, Westland petrel, Fairy prion, Broad-billed prion, White-faced storm petrel, Cook's petrel, Mottled petrel	*Puffinus griseus, Puffinus huttoni, Pelecanoides urinatrix, Pelecanoides georgicus, Procellaria westlandica, Pachyptila turtur, Pachyptila vittata, Pelagodroma marina, Pterodroma cookii and Pterodroma inexpectata*
	Toroa	Albatrosses/Mollymawks	*Diomedea spp*
Marine Mammals	Ihupuku	Southern elephant seal	*Mirounga leonina*
	Kekeno	New Zealand fur seals	*Arctocephalus forsteri*
	Paikea	Humpback whales	*Megaptera novaeangliae*
	Parāoa	Sperm whale	*Physeter macrocephalus*
	Rāpoka/Whakahao	NZ sea lion	*Phocarctos hookeri*
	Tohorā	Southern right whale	*Eubalaena australis*
Fish	Kāeo	Sea tulip	*Pyura pachydermatum*
	Koeke	Common shrimp	*Palaemon affinis*
	Kōkopu/Hawai	Giant bully	*Gobiomorphus gobioides*
	Kōwaro	Canterbury mudfish	*Neochanna burrowsius*
	Paraki/Ngaiore	Common smelt	*Retropinna retropinna*
	Piripiripōhatu	Torrentfish	*Cheimarrichthys fosteri*
	Taiwharu	Giant kōkopu	*Galaxias argenteus*
Shell-fish	Pipi/Kākahi	Pipi	*Paphies australe*
	Tuaki	Cockle	*Austrovenus stutchburgi*
	Tuaki/Hākiari, Kuhakuha/Pūrimu	Surfclam	*Dosinia anus, Paphies donacina, Mactra discor, Mactra murchsoni, Spisula aequilateralis, Basina yatei*, or *Dosinia subrosa*
	Tuatua	Tuatua	*Paphies subtriangulata, P. donacina*
	Waikaka/Pūpū	Mudsnail	*Amphibola crenata, Turbo smaragdus, Zedilom* spp

Appendix E
Report Number 740.10032.00200

MARINE MAMMAL MITIGATION PLAN

Marine Mammal Mitigation Plan (MMMP)

Marine Seismic Survey

Report No. 40009-MMMP

Client	**Schlumberger New Zealand**
Area	**New Zealand**
Survey	**Pegasus Basin 3D Survey**
PPP Permit No.	**60264.01**
Dates	**November 2016 – July 2017**
Vessel	**Amazon Warrior**

TABLE OF CONTENTS

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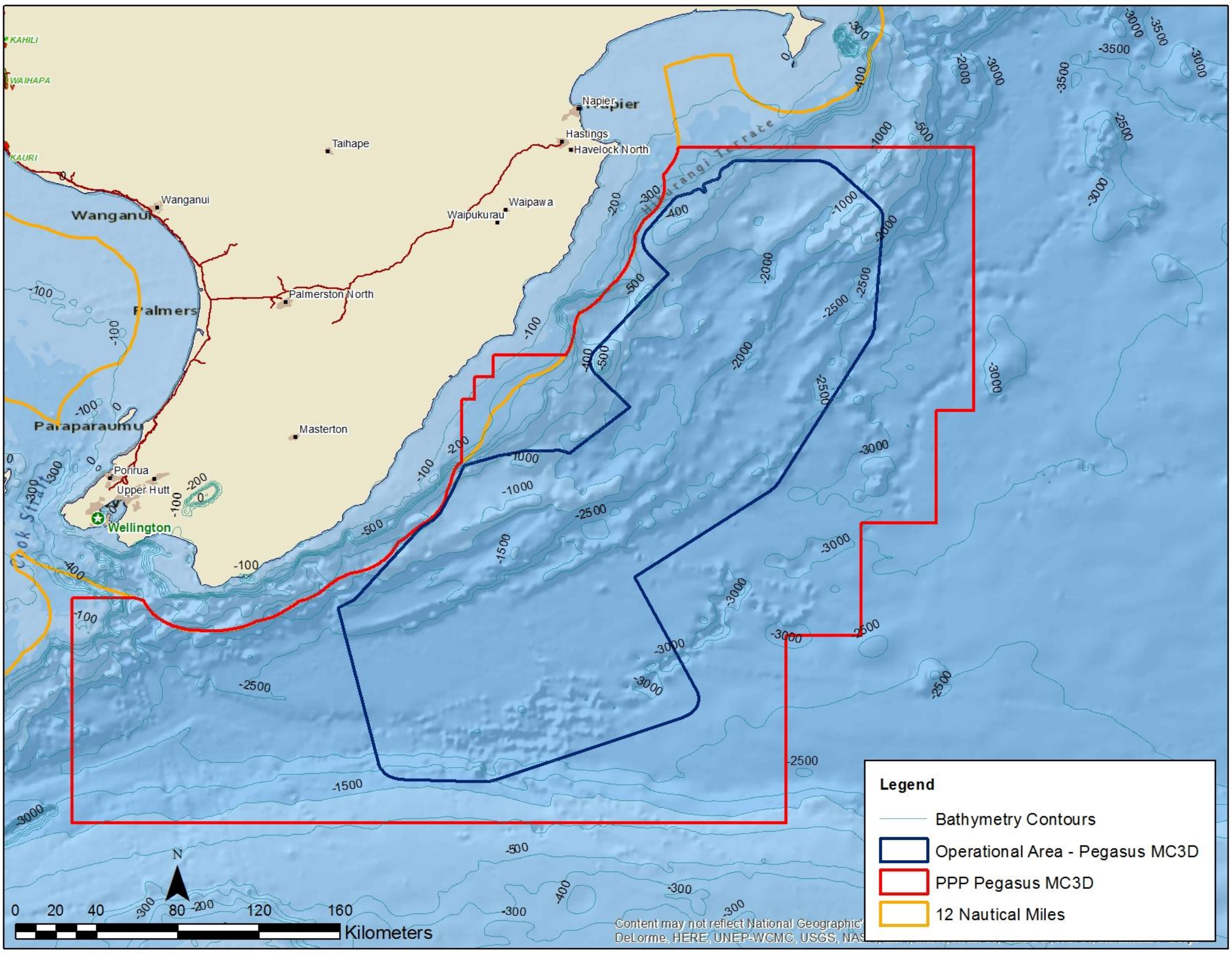
QA Checked by	Ben Dyton / Dan Govier

1.0 Overview

Schlumberger New Zealand (Schlumberger) plans to undertake a 3-Dimensional (3D) marine seismic survey (MSS) located in the East Coast and Pegasus Basin, off the central east coast of New Zealand. The Operational Area reaches from Napier in the North Island, south to Kaikoura on the South Island. The survey does include a small section of territorial sea near Castlepoint (Wairarapa). Water depths in the Operational Area range from 400 to 3,250m. The proposed project referred to as "Pegasus Basin Seismic Survey" is scheduled to commence November 2016 and continue until June 2017 with an approximate duration of six months.



Operational Area – Pegasus MC/3D

The *M/V Amazon Warrior* will be used for the survey and will tow a 5,085 in^3 acoustic source that will be activated every eight seconds. The seismic vessel will tow 14 streamers of approximately 8km in length with streamers separated by 100m equalling a total span of 1,300m. The vessel will undertake the survey travelling approximately four to five knots. Seismic operations will continue around the clock (as possible) and will utilise continuous line acquisition (acquiring seismic data through the turns) to reduce the overall duration of the survey. The Pegasus Basin Survey qualifies as a Level 1 Survey by the Code of Conduct defined by the Code as a large scale geophysical survey (.>427 cubic inches).

Acoustic disturbance from seismic surveys is considered to be the most significant potential effect from the Pegasus Basin Survey, and compliance with the Code of Conduct is the primary mitigation measure proposed. This Marine Mammal Mitigation Plan (MMMP) outlines the necessary mitigation measures for a Level 1 Survey. These measures include 1) the presence of marine mammal observers (MMOs) and passive acoustic monitor (PAM) operators whose role is to visually and acoustically detect marine mammals, 2) the use of delayed starts if marine mammals are detected in close proximity to the acoustic source before operations commence, 3) the use of 'soft starts' to ensure that any undetected marine mammals have an opportunity to leave the vicinity before full operational power is reached, and 4) shut downs of the acoustic source if marine mammals enter the defined mitigation zones. In the territorial sea and in waters outside the

EEZ, but over the Continental Shelf, compliance with the Code is voluntary and is neither legally binding nor enforceable. Schlumberger has agreed to comply with the Code of Conduct through the entire Operational Area.

Since vessel presence is another potential impact to marine mammals due to disruption of normal behaviour, displacement of individuals, ship strikes, and entanglement risks, MMOs will be stationed on the bridge during good weather while the vessel is in transit to and from the Operational Area in order to maximise data collected during the survey.

The Pegasus Basin Seismic Survey will also largely occur within an Area of Ecological Importance. A summary of the measures that Schlumberger will implement to offset their potential effects in this area is provided in Section 7.

Marine mammal strandings in the vicinity of the seismic survey may be identified for necropsy to investigate potential acoustic injury though no scientific evidence currently supports whale strandings are linked to seismic surveys. MMOs will observe for entanglement incidents and will report any dead marine mammals observed at sea. Schlumberger have agreed to consider covering the cost of any necropsies on a case-by-case basis in the event of marine mammals strandings if a stranding occurs during the survey inshore of the Operational Area or within two weeks of survey end.

Marine turtles are unlikely to occur within the Operational Area. In the event a turtle is present in close proximity to the vessel some behavioural changes may occur but they are considered to be minor so no mitigation measures are in place.

There are 38 species of cetaceans that are potentially present within the Survey Area. These species are outlined below in Table 1. as described in the Marine Mammal Impact Assessment for the Pegasus Basin Survey (SLR, 2016). A basic ecological summary for those species considered 'likely' to be present in the Operational Area, 'occasional visitors', or those considered to be threatened species is described in the table.

Table 1. Cetacean Species Potentially Present in the Survey Area

Species	Scientific Name	NZ Threat Status	Species of Concern	IUCN Status	Likelihood of Occurrence	Season most likely present
Southern right whale	*Eubalaena australis*	**Nationally vulnerable**	Yes	Least concern	**Likely**	Year round
Pygmy right whale	*Caperea marginata*	Data Deficient	Yes	Data deficient	**Possible**	Year round*
Antarctic minke whale	*Balaenoptera bonarensis*	Not threatened	Yes	Data deficient	**Likely**	Year round, except summer
Dwarf minke whale	*Balaenoptera acutorostrata*	Not threatened	Yes	Data deficient	**Possible**	Year round, except summer
Sei whale	*Balaenoptera borealis*	Migrant	Yes	Endangered	Occasional visitor	Year round*
Bryde's whale	*Balaenoptera edeni*	**Nationally critical**	Yes	Data deficient	**Likely**	Summer
Antarctic blue whale	*Balaenoptera musculus intermedia*	Migrant	Yes	Endangered	Occasional visitor	Year round, except summer
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Migrant	Yes	Endangered	Occasional visitor	Year round
Fin whale	*Balaenoptera physalus*	Migrant	Yes	Endangered	Occasional visitor	Year round*
Humpback whale	*Megaptera novaeangliae*	Migrant	Yes	Least concern	Occasional visitor	May – August (northern migration)
Sperm whale	*Physeter microcephalus*	Not threatened	Yes	Vulnerable	**Likely**	Year round
Pygmy sperm whale	*Kogia breviceps*	Not threatened	Yes	Data deficient	Likely	Year round*
Dwarf sperm whale	*Kogia sima*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Arnoux's beaked whale	*Beradius arnouxi*	Migrant	Yes	Data deficient	Occasional visitor	Year round*
Andrew's beaked whale	*Mesoplodon bowdoini*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Blainville's beaked whale	*Mesoplodon densirostris*	Data deficient	Yes	Data deficient	Unlikely	Year round*
Ginko-toothed whale	*Mesoplodon ginkgodens*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	Yes	Data deficient	**Likely**	Year round*
Hector's beaked whale	*Mesoplodon hectorii*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Strap-toothed whale	*Mesoplodon layardi*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Lesser/pygmy beaked whale	*Mesoplodon peruvianus*	Vagrant	Yes	Data deficient	Unlikely	Year round*
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	No	Data deficient	Unlikely	Year round*
Shepherd's beaked whale	*Tasmacetus shepheri*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	Yes	Data deficient	**Possible**	Year round*
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	Yes	Least Concern	Unlikely	Year round*
South Island Hector's dolphin	*Cephalorhynchus hectori hectori*	**Nationally endangered**	Yes	Endangered	Unlikely**	Winter
Common dolphin	*Delphinus delphis*	Not threatened	No	Least concern	**Likely**	Year round
Short-finned pilot whale	*Globicephala macrorhynchus*	Migrant	Yes	Data deficient	Unlikely	Summer
Long-finned pilot whale	*Globicephala melas*	Not threatened	Yes	Data deficient	**Likely**	Year round
Risso's dolphin	*Grampus griseus*	Vagrant	No	Least concern	Rare visitor	Year round*
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	No	Least concern	Unlikely	Year round*
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	No	Data deficient	**Likely**	Year round
Southern right whale dolphin	*Lissodelphis peronei*	Not threatened	Yes	Data deficient	Unlikely	Year round*
Killer whale	*Orcinus orca*	**Nationally critical**	Yes	Data deficient	**Likely**	Year round
False killer whale	*Pseudorca crassidens*	Not threatened	Yes	Data deficient	Likely	Year round*
Spotted/striped dolphin	*Stenella sp.*	Vagrant	No	Least concern	Unlikely	Summer
Rough-toothed dolphin	*Steno bredanensis*	Vagrant	No	Least concern	Unlikely	Year round*
Bottlenose dolphin	*Tursiops truncatus*	**Nationally endangered**	Yes	Least concern	**Likely**	Year round*

(Inserted from Schlumberger Marine Mammal Impact Assessment for Pegasus Basin Survey Report No. 740 10032 00200)

*Limited data on which to base seasonality assessment, hence a year round presence has been assumed

**Despite a presence in stranding and sighting record from inshore of the survey area, unlikely to be present within the survey area on account of its offshore nature

2.0 Level One Survey Requirements

2.1. Observer Requirements

The minimum qualified observer requirements will be:

- At all times there will be at least two qualified MMOs on board;
- At all times there will be at least two qualified PAM operators on board. Details of the PAM system to be used during the MMS are provided at the end of this plan and are considered appropriate to meet the requirements of the Code;
- The qualified observers will be dedicated in that their roles on the vessel are strictly for the detection and data collection of marine mammal sightings, and instructing crew on their requirements when a marine mammal is detected within the relevant mitigation zone (the standard radius set out in the Code which incorporated the results from the sound transmission loss modelling);
- Marine mammal sightings will be collected whilst on transit to and from the Survey Area to the local point as well as during the length of the survey;
- At all times while the acoustic source is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain watched for marine mammals; and,
- One local trained IWI observer will be included on each rotation per consultation requirements.

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

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

- It is daylight 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 PAM system; and,
- Operations with an active source, but without active PAM system, do not exceed a cumulative total of four hours in any 24-hour period.

2.2. Pre-Start Observations

Normal Requirements

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

The source will not be activated during daylight hours unless:

- At least one qualified MMO has continuously made visual observations all around the source for the presence of marine mammals, from the bridge (or preferably an even higher vantage point) using both binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least ten minutes; and,
- Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalizing cetaceans have been detected in the relevant mitigation zones.

The source will not be activated during night-time hours or poor sighting conditions (visibility of 1.5km or less or in a sea state greater than or equal to Beaufort 4) unless:

- PAM for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation; and,

- The qualified observer has not detected vocalizing cetaceans in the relevant mitigation zones.

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

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

- MMOs have undertaken observation within 20 nautical miles 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; or,
- Where there have been less than two hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if:
  - PAM monitoring has been conducted for two hours immediately preceding proposed operations; and,
  - Two MMOs have conducted visual monitoring in the two hours immediately preceding proposed operations; and,
  - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the two hours immediately preceding proposed operations; and,
  - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the ten minutes immediately preceding proposed operations; and,
  - No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

2.3. Delayed Starts and Shutdowns

The results of the Sound Transmission Loss Modelling (STLM) indicated the standard mitigation zones for delayed starts and shutdowns (as outlined in the Code of Conduct) are sufficient to protect marine mammals from behavioural and physiological effects during the Pegasus Basin Seismic Survey.

The following thresholds as defined by the Code are used to determine the mitigation zones for the survey.

- The behavioural threshold is exceeded if marine mammals are subject to Sound Exposure Levels (SELs) greater than 171 dB re 1µPa^2-s; and,
- The physiology threshold is exceeded if marine mammals are subject to SELs greater than 186 dB re 1µPa^2-s (also known as injury threshold).

Therefore, it was determined by the STLM the following mitigation zones be utlised.

- Agreed mitigation zone for other marine mammals = 200m;
- Agreed mitigation zone for Species of Concern = 1,000m (1km); and,
- Agreed mitigation zone for Species of Concern with calves – 1,500m (1.5km).

The standard mitigation zones for the Survey are outlined below.

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

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

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

Species of Concern within a Mitigation Zone of 1.0km

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

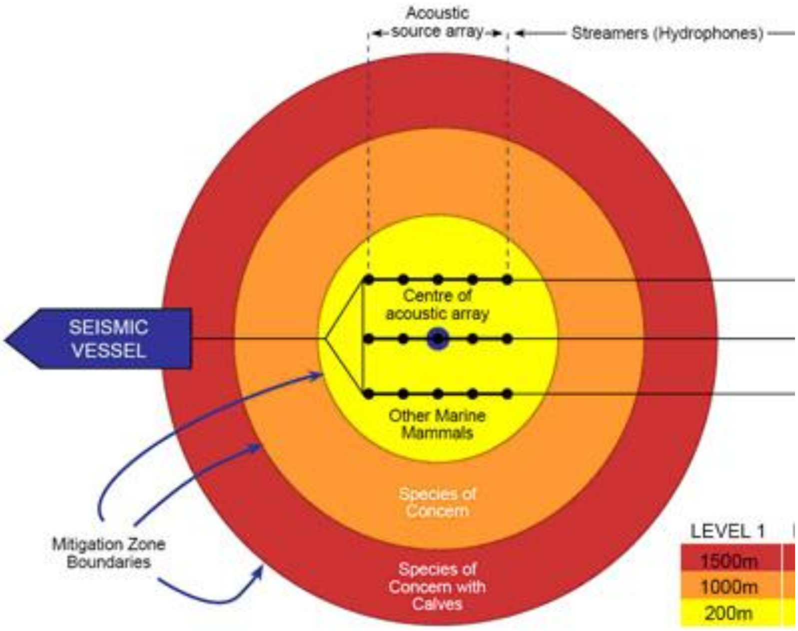
- A qualified observer confirms the Species of Concern has moved to a point that is more than 1.0km from the source; or,
- Despite continious observation, 30 minutes has elapsed since the last detection of the Species of Concern within 1.0km of the source, and the mitigation zone remains clear.

Other Marine mammals within a Mitigation Zone of 200m

If, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200m of the source, start up will be delayed until:

- A qualified observer confirms the marine mammal has moved to a point that is more than 200m from the source; or,
- Despite continious observation, 10 minutes has passed since the last detection of a New Zealand fur seal within 200m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200m of the source, and the mitigation zone remains clear.

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

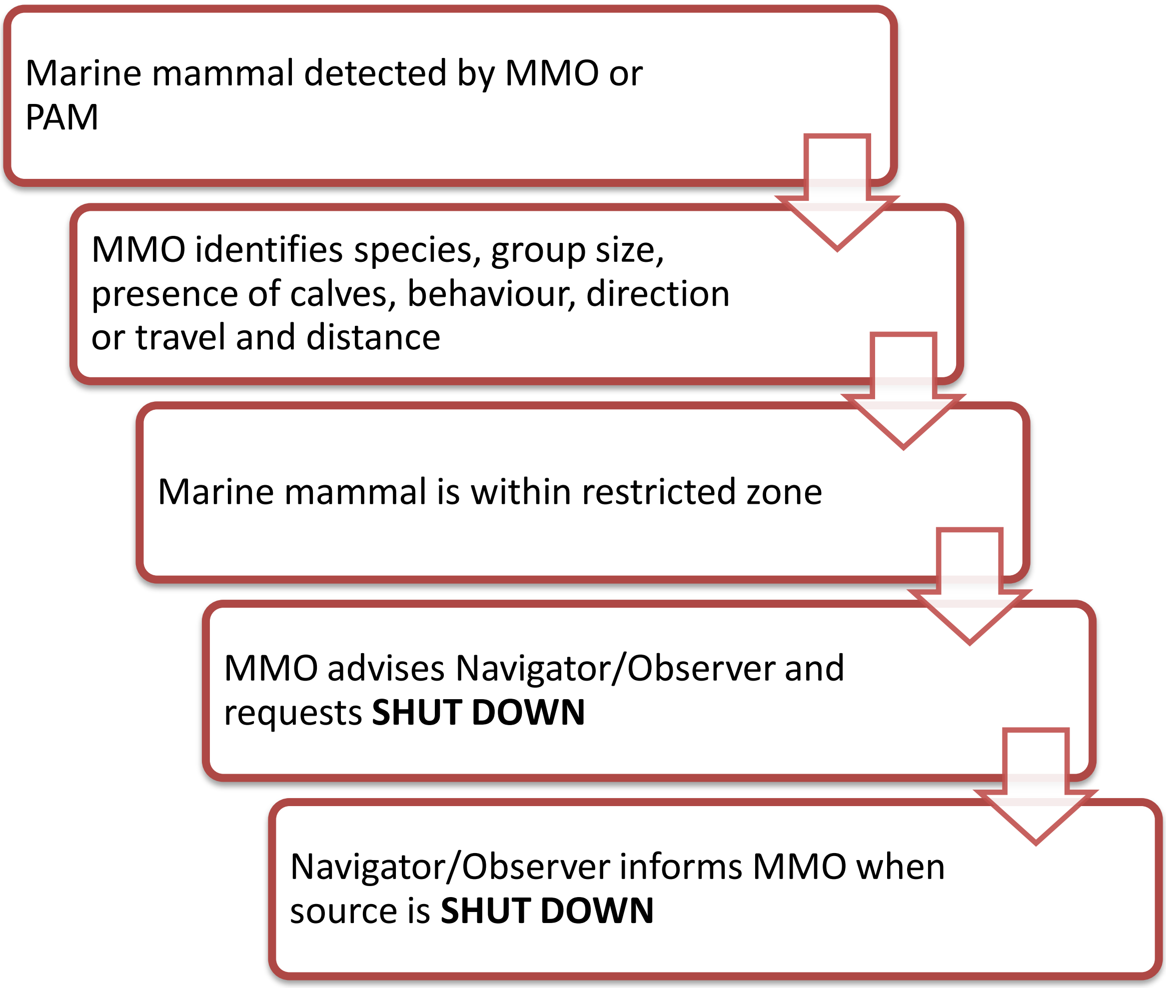


Mitigation Zones in Relation to the Sound Source

3.0 Communications Flow

3.1. Communication Process

The below figures depict the communication process between the MMO and survey personnel in the event of marine mammal sightings.



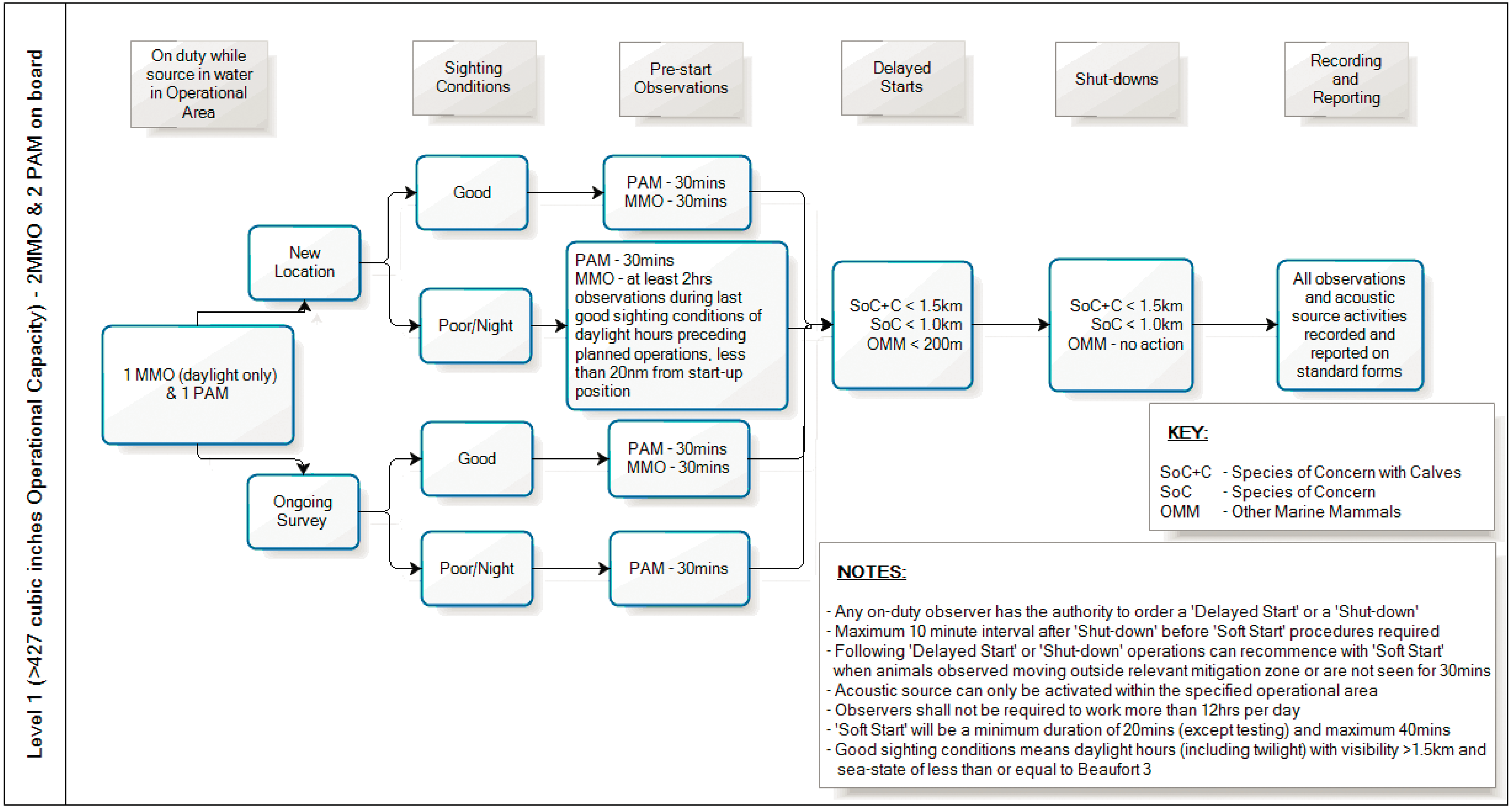
MMO advises Navigator/Observer **ALL CLEAR** when marine mammals exit the restricted zone or not detected within 30 minutes

MMO advises Navigator/Observer **ALL CLEAR** when whales exit the restricted zone or not detected within 30 minutes

Navigator/Observer informs MMO when **SOFT START** about to commence

30 minute **SOFT START** commences

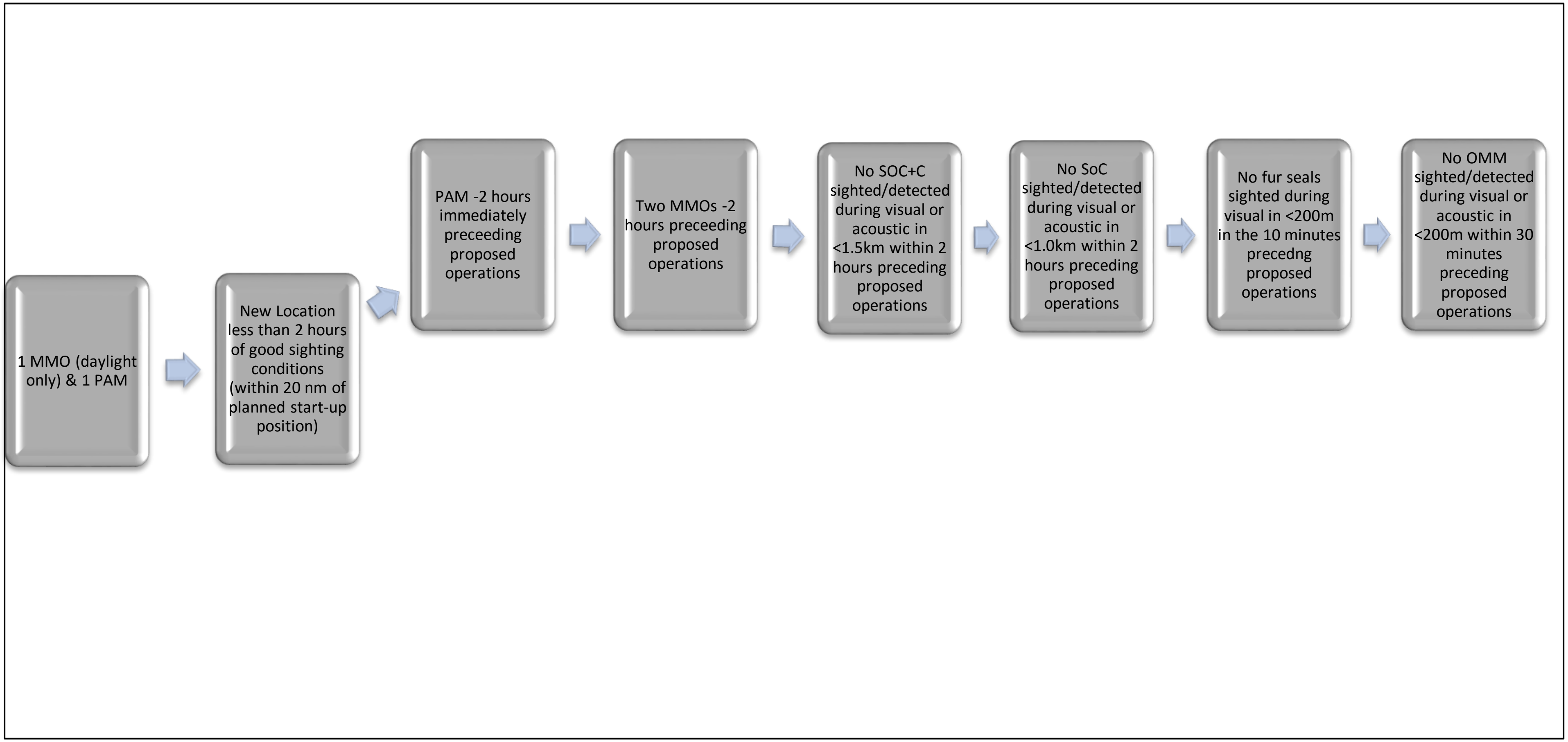
MMO advises Navigator/Observer **ALL CLEAR** when no marine mammals observed within the restricted zone during **SOFT START** and normal operations may commence



(Inserted from DOC Code of Conduct)

*Alternate options for start-up in a new location in poor conditions with less than two hours of good sighting conditions prior to start-up is detailed in the below figure

The below figures depict the process for alternate options for start-up in a new location in poor conditions when there have not been two hours of good sighting conditions prior to start-up. For further details, please refer to page 7 of this document.



- SoC+C = Species of Concern with Calves; SoC = Species of Concern; OMM = Other Marine Mammals

4.0 Operational Detailed Requirements

4.1. Observer Effort

Of the two qualified MMOs and two qualified PAM operators on board, as a minimum one MMO will be on watch during daylight hours and one PAM operator will be on watch during all hours while the acoustic source is in the water in the Operational Area.

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

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

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

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

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

4.2. Marine Mammal Observer Duties

While acting in their designated role, MMOs will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for on board operations;
- Continually scan the water surface in all directions around the acoustic source (not the vessel) for presence of marine mammals, using a combination of naked eye and high-quality binoculars, from optimum vantage points for unimpaired visual observations with minimum distractions;
- Use GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards, or and 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;
- Communicate with the Director-general to clarify any uncertainty or ambiguity in application of the Code;
- Record and report any instances of non-compliance with the Code; and,
- Notify the Director-General immediately if higher numbers of cetaceans and/or species of concern are encountered than predicted in the MMIA and in the event of a non-compliance with the Code.

4.3. Passive Acoustic Monitor Operator Duties

While acting in their designated role, PAM operators will:

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

4.4. Authority to Shut Down or Delay Starts

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

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

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

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

4.5. Observer Deployment

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

4.6. Crew Observations

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

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

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

4.7. Acoustic Source Power Output

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

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

4.8. Soft Starts

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

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

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

The source volume of the three sub-arrays is 5,085 in^3. The source volume is not to be exceeded during the soft start process including if redundant sources are activated for testing during soft start. Observers are required to communicate this to the crew and monitor for their compliance.

4.9. Acoustic Source Tests

Seismic source tests will be subject to the relevant soft start procedures for a Level 1 survey, though the 20-minute duration does not apply. Where possible, power will be built up gradually to the required test level at a rate not exceeding that of a normal soft start (no more than 40 minutes).

Level 1 seismic source tests with a maximum combined source capacity of <2.49 litres or 150 cubic inches do not require soft start procedures, and can be undertaken following relevant pre-start observations.
Acoustic source tests will not be used for mitigation purposes, or to avoid implementation of soft start procedures.

4.10. Line Turns

Schlumberger will run a system of 'continuous line acquisition' by shortening the lines and acquiring data during the turns so Schlumberger can optimise vessel use and reduce the overall duration of the survey. The larger survey was considered optimal by DOC instead of smaller, more frequent surveys. The goal is to reduce down time on the survey to minimise overlap with winter baleen whale migrations from the Southern Ocean to northern waters.

4.11. Recording and Reporting Requirements

All sightings of marine mammals during the survey period, including any beyond the maximum mitigation zone boundaries or while in transit, will be recorded in the OFF survey excel reporting form. All sightings of marine mammals during the survey period in the Operational Area will be recorded in the ON survey excel reporting form. A written trip report (Final Survey Report) will be submitted by Schlumberger to the Director-General no longer than 60 days after completion of the survey. In addition, weekly reports will be provided by Schlumberger to DOC and EPA.

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

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

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

The MMOs will report any dead marine mammals observed while at sea to DOC with location and species type if achievable, and shall notify DOC immediately should any live sightings of Hector's/Maui's dolphins be made.

4.12. Report Contents

The following will be included in the Final Survey Report being produced:

  - The identity, qualifications and experience of those involved in observations;
  - Observer effort, including totals for watch effort (hours and minutes);
  - Observational methods employed;
  - Name of the operator and any vessels/aircraft used;
  - Specifications of the seismic source array, and PAM array;
  - Position, date, start/end of survey, GPS track logs of vessel movements;
  - Totals for seismic source operations (hours and minutes) indicating respective durations of full-power operation, soft starts and acoustic source testing, and power levels employed, plus at least one ransom soft start sample per swing;
  - Sighing/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 keys for species or lowest taxonomic level;
    - Confidence level of identification;
    - Descriptions of distinguishing features of individuals where possible;
    - Acoustic source activity and power at time of sighting;
    - Environmental conditions;
    - Water depth; and,
    - For PAM detections, time and duration heard, type, and nature of sound.
- General location, time, duration and reasons where observations were affected by poor sighting conditions;
- Position, time and number of delays and shutdowns initiated in response to the presence of marine mammals;

- Position, duration and maximum power attained where operational capacity exceeded;
- An instances of non-compliance;
- Differentiation will be made between data derived from:
  - MMO and PAM Operators;
  - Qualified observers and others; and,
  - Watches during survey operations (ON survey) or at other times (OFF survey).

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

5.0 PAM System & Specifications

5.1. PAM Specifications

Cetacean Detection Capability

The vocalisations made by the full range of marine mammal species can be detected by our PAM systems. Typical system configuration has the capability of detecting sounds within a frequency range of 200 Hz to 200 kHz. This frequency band covers most marine mammal vocalisations. The system sensitivity may be extended to 10 Hz to 200 kHz for surveys in which it is necessary to monitor for baleen whales that vocalise at very low frequencies. However, in some circumstances, vessel noise at low frequencies can mask marine mammal vocalisations and limit the performance of PAM. The frequency response of some hydrophone channels is set to counter this (e.g. lower frequency response of 2 kHz for channels designed to detect the majority of species vocalisations). Seiche can readily tailor the frequency sensitivity of the hardware to suit the project application and the range of marine mammal species likely to be encountered. Additionally, PAMGuard software can be configured to focus on the detection of the vocalisations of particular species of interest or concern.

PAMGuard Software

PAMGuard software is integrated into all our PAM systems. PAMGuard is industry-standard software for the acoustic detection, localization and classification of vocalizing marine mammals. It is a sophisticated and extendible software package that assists trained operators in robust decision-making during real-time mitigation operations. As an open source development, PAMGuard is publicly owned and freely available. PAMGuard development is led by a team of specialists at the University of St Andrews, U.K. This has to date been funded by industry via the IOGP Sound and Marine Life Joint Industry Program. Funding is now transitioning to a self-funding mechanism operated through voluntary user contributions.

Table 2. Hydrophone elements frequency range

Hydrophone Elements	
H1	10 Hz to 200 kHz (-3 dB points)
H2	10 Hz to 200 kHz (-3 dB points)
H3	2 Hz to 200 kHz (-3 dB points)
H4	2 Hz to 200 kHz (-3 dB points)

Table 3. Hydrophone sensitivity

Hydrophone sensitivity	
Broadband channel sensitivity	-166 dB re 1V/µPa (nominal)
Standard channel sensitivity	-157 dB re 1V/µPa (nominal)

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