TURANGI 3D SEISMIC SURVEY

Marine Mammal Impact Assessment
North Taranaki

Prepared for:

NZ Surveys 2020 Limited
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Auckland

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with NZ Surveys 2020 Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

NZ Surveys 2020 Limited (**NZSL**) is proposing to undertake the Turangi 3D Seismic Survey in coastal waters of North Taranaki in March/April 2022. The Turangi 3D Seismic Survey is planned as a transitional seismic survey to fill a data gap between an existing marine 3D seismic survey and land-based 3D seismic data. This survey will utilise a boat-based acoustic source and an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system. Two options for source level have been included in this report as the final array will be confirmed closer to acquisition time. The source will be either 1,000 in^3 or 1,420 in^3.

The Turangi 3D Seismic Survey will be undertaken in accordance with the Taranaki Regional Coastal Plan and the West Coast North Island Marine Mammal Sanctuary which both requires compliance with the Department of Conservation (**DOC**) 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (**Code of Conduct**). Under the Code of Conduct, a Marine Mammal Impact Assessment (**MMIA**) is required in order to describe the proposed seismic operations, provide a description of the baseline environment, identify any potential environmental effects from the seismic operations, and to specify any proposed mitigation measures to minimise environmental effects. Where seismic activities are undertaken within an Area of Ecological Importance, Sound Transmission Loss Modelling (**STLM**, **Appendix A**) is also required.

Two operational areas are proposed; these being the Primary Operational Area along the coastline of Onaero, North Taranaki within the Coastal Marine Area (**CMA**) where seismic data will be collected, and a 1 km x 1 km acoustic source and Testing Area off New Plymouth. The acoustic source will only be operated within these two defined areas. However, in order to determine the potential environmental effects of the Turangi 3D Seismic Survey, a broader Area of Interest (**AOI**) has been assessed which encompasses both the Primary Operational Area and Testing Area and accounts for the large home-ranges of marine mammals that could occur in the region. It is noteworthy that the Primary Operational Area and Testing Area are located within the boundaries of the West Coast North Island Marine Mammal Sanctuary and is within an Area of Ecological Importance.

NZSL's proposed survey falls within the classification of a Level 1 marine seismic survey due to the source volume (i.e. > 427 in^3 acoustic source). Compliance with the Code of Conduct for a Level 1 marine seismic survey is the primary mitigation measure that NZSL will employ during the Turangi 3D Seismic Survey. The full protocol of operational procedures and control measures that will be followed during the Turangi 3D Seismic Survey is detailed within the Marine Mammal Mitigation Plan (**Appendix D**) which will provide a working document during the survey.

Utilising data within the DOC stranding and sighting database, and knowledge of migration paths and habitat preferences of each marine mammal species (obtained from published scientific literature), common dolphin, killer whale, New Zealand fur seal, and southern right whales are *likely* to be present within the AOI; whereas Cuvier's beaked whale, dusky dolphin, Hector's dolphin, humpback whale, long-finned pilot whale, Māui's dolphin, pygmy blue whale, pygmy right whale, Shepard's beaked whale, sperm whale and strap-toothed whales are considered to have a *possible* presence within the AOI.

An Environmental Risk Assessment process has been utilised within this MMIA to assess the significance of any predicted effects on the environment of relevance to the Primary Operational Area and Testing Area. NZSL has undertaken consultation with stakeholders and tangata whenua in relation to the Turangi 3D Seismic Survey. This consultation process involved groups being consulted in person, by telephone, and by email correspondence.

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This MMIA has identified all the potential environmental effects that may arise from the Turangi 3D Seismic Survey and describes the mitigation measures that NZSL will implement to ensure that any potential effects are reduced to levels that are as low as reasonably practicable. While this MMIA focuses on potential effects on marine mammals, effects on other environmental and socio-economic receptors have also been considered. The following mitigation measures will be employed by NZSL throughout the duration of the Turangi 3D Seismic Survey to mitigate against any potential effects:

- Seismic acquisition will only occur during daylight hours;
- Compliance with the Code of Conduct including the following key points:
    - Two Marine Mammal Observers (**MMOs**) and two Passive Acoustic Monitoring Operators (**PAM Operators**) will be stationed on the source vessel. Both MMOs and at least one PAM Operator will be on duty at all times when the source is in the water. The 'on duty team' will be supported by the additional PAM Operator who will provide cover for both MMO and PAM roles as needed;
    - The standard mitigation zones within the Code of Conduct will be used for delayed starts and shut-downs. STLM has confirmed that the survey complies with the regulatory mitigation zone Sound Exposure Level (**SEL**) requirements defined within the Code of Conduct;
    - Pre-start observations from the source vessel will be carried out for at least 30 minutes prior to activating the acoustic source. The acoustic source will only be activated in the event that no marine mammals (other than New Zealand fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no New Zealand fur seals have been observed in the relevant mitigation zone for at least 10 minutes;
    - Additional pre-start observation requirements will be followed at the commencement of each day's operations if sighting conditions are poor;
    - If a marine mammal is detected within the relevant mitigation zone, the acoustic source will be shut-down or start-up will be delayed until the MMOs or PAM Operators confirm the animal has left the mitigation zone (or no further detections have been made) for the required period of time;
    - Activation of the acoustic source will only occur following the soft-start procedures after the above observation period; and
- Compliance with all required and relevant regulations and conventions to ensure safety of all crew and other marine users and to avoid adverse effects on the marine environment from potential discharges and vessel collisions.

In addition to the above mitigation measures, the following commitments are made:

- Immediate notification to DOC of any Hector's/Māui's dolphin sightings;
- Advanced notification to DOC Taranaki of when the source is likely to be activated;
- Vessel crew onboard the survey vessels will at all times remain vigilant for sightings of little blue penguins. Observations of little blue penguins will be included in daily observations and reported alongside the required marine mammal observations; and
- In the event that a stranding occurs during the survey, or within two weeks following the completion of the survey NZSL will, on a case-by-case basis, consider covering the cost of a necropsy in an attempt to determine the cause of death. NZSL will seek advice from DOC as to the requirement for a necropsy.

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STLM has been used to verify the sound thresholds for the standard mitigation zones specified within the Code of Conduct. The short range modelling prediction demonstrates that the maximum received SEL is predicted to comply with the limits of 186 dB re 1 µPa^2·s at 200 m, and 171 dB re 1 µPa^2·s at 1.0 km and 1.5 km.

Overall, the predicted effects of the Turangi 3D Seismic Survey are considered to be sufficiently managed by the proposed mitigation measures, predominantly compliance with the Code of Conduct and restriction of acoustic operations to daylight hours. STLM demonstrates that physiological effects would only occur out to a maximum of 400 m from the acoustic source, therefore, the mitigation zones prescribed by the Code of Conduct will be highly protective to marine mammals. While some behavioural effects and masking may occur beyond 400 m, the short duration of the survey and the relatively low level of use of the AOI by marine mammals reduces the possibility of these effects being of any ecological significance.

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ABBREVIATIONS AND DEFINITIONS

µPa	Micro-pascal
AOI	Area of Interest
CMA	Coastal Marine Area
Code of Conduct	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
dB	Decibels
DOC	Department of Conservation
FMA	Fisheries Management Area
FNZ	Fisheries New Zealand
Hz	Hertz
IUCN	International Union for Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships 1973 as Modified by the Protocol of 1978
MMIA	Marine Mammal Impact Assessment
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Mammal Observer
NIWA	National Institute of Water and Atmospheric Research
NM	Nautical Mile
NZSL	NZ Surveys 2020 Ltd.
PAM	Passive Acoustic Monitoring
PCP	Proposed Coastal Plan for Taranaki
PMP	Petroleum Mining Permit
QMS	Quota Management System
SEL	Sound Exposure Level
STLM	Sound Transition Loss Modelling
TRC	Taranaki Regional Council

1 Introduction

NZ Surveys 2020 Limited (**NZSL**) seeks to commence the Turangi 3D Seismic Survey in coastal waters of North Taranaki in March/April 2022. The Turangi 3D Seismic Survey is planned as a transitional seismic survey to fill a data gap between an existing marine 3D seismic survey and land-based 3D seismic data. This survey will utilise a boat-based acoustic source and an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system. Two options for source level have been included in this Marine Mammal Impact Assessment (**MMIA**) as the final array will be confirmed closer to acquisition time. The source will be either 1,000 in^3 or 1,420 in^3.

Two operational areas are proposed; one being the primary acquisition area along the coastline of Onaero, North Taranaki within the Coastal Marine Area (**CMA**) (labelled as 'Turangi 3D Operational Area' in **Figure 1**, and hereafter referred to as the **Primary Operational Area**), and the second being a 1 km x 1 km acoustic source testing area off New Plymouth (labelled as 'Turangi 3D Testing Area' in **Figure 1**, and hereafter referred to as the **Testing Area**). The acoustic source will only be operated within these two defined areas.

Activities associated with the Primary Operational Area will largely be undertaken within the offshore component of Petroleum Mining Permit (**PMP**) 38161. On 31 January 2022 New Zealand Petroleum and Minerals has granted written authorisation (under section 42A of the Crown Minerals Act 1991) for geophysical surveys to be undertaken outside PMP 38161 and a subsequent extension on 10 November 2020 was granted to cover the Primary Operational Area. The source testing will occur within PMP 50509.

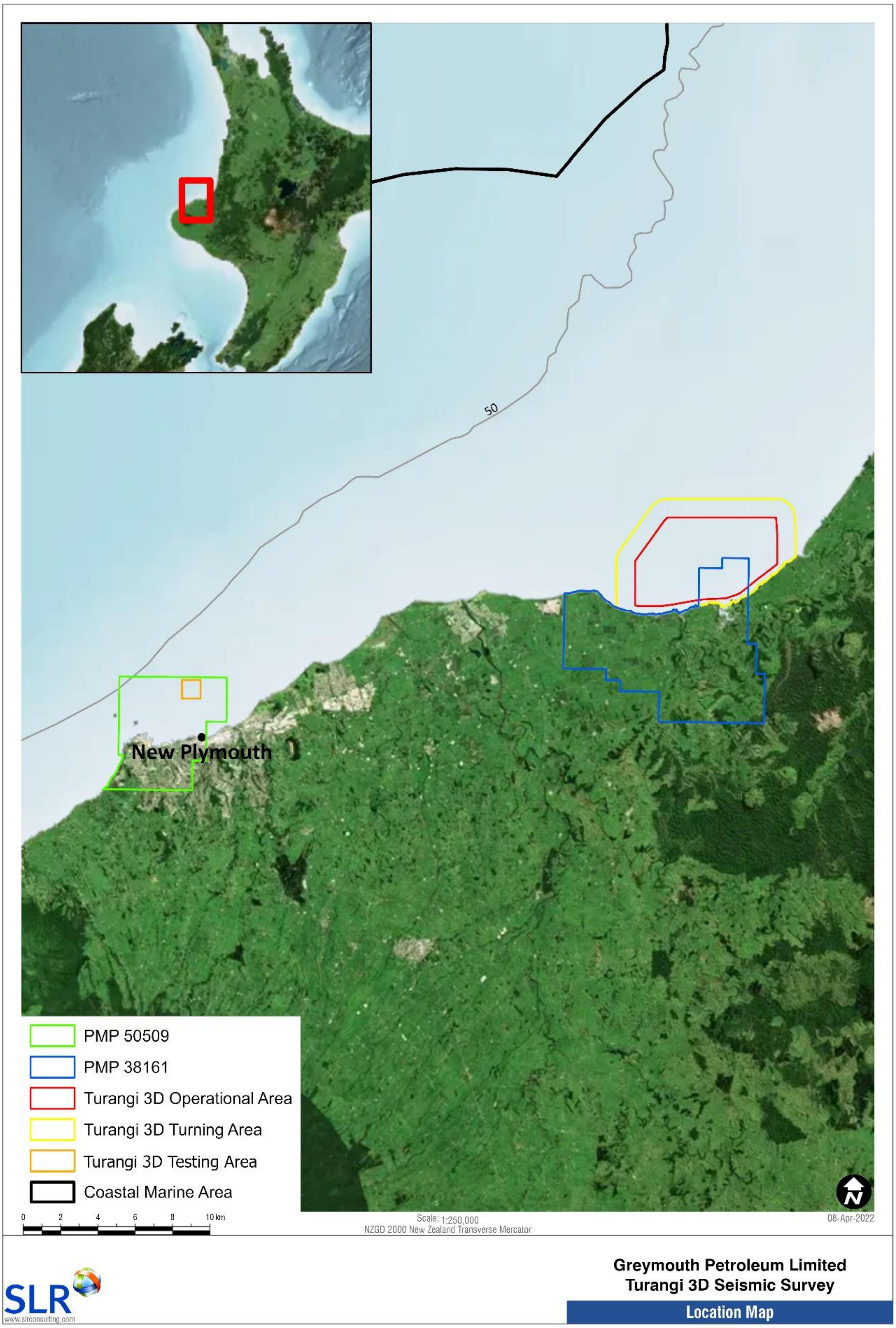
The legislative framework that relates to the proposed Turangi 3D Seismic Survey is described in detail in **Section 3**. Of primary relevance is the Proposed Taranaki Coastal Plan for Taranaki (**PCP**) and the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008; both of which require compliance with the Department of Conservation (**DOC**) 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (**Code of Conduct**).

This MMIA is an integral component to ensure that NZSL undertakes the Turangi 3D Seismic Survey in adherence with the legislative requirements. The Code of Conduct requires Sound Transmission Loss Modelling (**STLM**) to be undertaken for any seismic surveys that will operate within an Area of Ecological Importance or within a Marine Mammal Sanctuary. STLM provides a 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 sound levels produced during the Turangi 3D Seismic Survey exceed the thresholds described in the Code of Conduct for mitigation zones. It is NZSL's intention to operate in full compliance with relevant New Zealand legislation, international conventions, and their internal environmental standards.

The Turangi 3D Seismic Survey is classified as a 'Level 1' survey by the Code of Conduct (i.e. > 427 in^3 acoustic source). The operational requirements for a Level 1 marine seismic survey include the use of marine mammal observers (**MMOs**) and passive acoustic monitoring (**PAM**) as outlined in **Section 3**. The specific protocol for MMO and PAM use is outlined in the Marine Mammal Mitigation Plan (**MMMP**) which is included as **Appendix E**.

An extensive review of literature and existing data on the environment has been undertaken as part of preparing this MMIA. A description of the existing environment is provided in **Section 5**. Published scientific literature has been used within **Section 6** in order to provide an assessment of the potential effects of the survey on the fauna described in **Section 5.2**. A full list of references used throughout this MMIA is provided in **Section 8**.

Figure 1 Location of Operational Areas



2 Project Description

2.1 Marine Seismic Surveys – Overview

The principle behind any marine seismic survey is that an energy source (i.e. acoustic source) instantaneously releases compressed air which generates a directionally focused acoustic wave at low frequency that can travel several kilometres through the Earth's crust. Portions of this acoustic wave are reflected by the underlying rock layers and the reflected energy is recorded by receivers (hydrophones) to determine the velocity of sound through the subsurface strata. Depths and spatial extent of the strata can be calibrated and mapped, based on the time difference of the energy being generated and subsequently recorded by the receivers.

2.1.1 Underwater Sound

Underwater sound has two primary measures:

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

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 sound in water the reference level is expressed as 'dB re 1 µPa' – the amplitude of a sound wave's loudness with a pressure of 1 micro-pascal (**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 mediums 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 gradients, currents, etc.). 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, and sonar further add to the underwater noise profile. The sound levels produced during a full-scale seismic survey are comparable to a number of naturally occurring and man-made sources (**Table 1**).

Table 1 Sound comparisons in air and water

Type of Sound	In Air (dB re 20 µPa @ 1m)	In Water (dB re 1 µPa @ 1m)
Threshold of Hearing	0 dB	62 dB
Whisper at 1 m	20 dB	82 dB
Normal conversation in restaurant	60 dB	122 dB
Ambient sea noise	-	100 dB
Blue whale	-	190 dB
Live rock music	110 dB	172 dB
Thunderclap or chainsaw	120 dB	182 dB
Large ship	-	200 dB
Earthquake	-	210 dB
Level 1 Seismic array at 1 m	158 – 203 dB	220 – 265 dB
Colliding iceberg	-	220 dB
Bottlenose dolphin	-	225 dB
Sperm whale click	-	236 dB
Jet engine take-off at 1 m	180 dB	242 dB
Volcanic eruption	-	255 dB

2.1.2 The Acoustic Source

The acoustic source is lowered into the water from a vessel. The source is comprised of two high-pressure chambers: an upper control chamber and a discharge chamber. High-pressure bottled nitrogen (compressed) is continuously fed to each source in the array, forcing a piston downwards. The chambers then fill with high-pressure air while the piston remains in the closed position.

Each element is activated by sending an electrical pulse to a 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, enabling the source arrays to be fired again when required.

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 column. The amplitude of sound waves 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 sources typically used by the oil and gas industry are designed to emit most of their energy at low frequencies, typically 20 – 50 Hz with declining energy at frequencies above 200 Hz (Popper *et al*., 2014). Total source levels range from ~222 – 264 dB when measured relative to a reference pressure of one micro-pascal (re 1 µPa-m$_{p-p}$) (Richardson *et al*., 1995).

2.2 Turangi 3D Seismic Survey

The Turangi 3D Seismic Survey is planned as a transitional seismic survey to fill a data gap between an existing marine 3D seismic survey and land 3D seismic survey. The Primary Operational Area is shown in **Figure 1**. This survey will utilise a boat-based acoustic source and an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system. The operational source will have an effective total volume of 1,000 or 1,420 in^3 and will be deployed approximately 3 m below the sea surface. The acoustic source will have an operating pressure of approximately 2,000 psi.

During the seismic survey the acoustic source will be lowered into the water column and towed behind a source vessel. The sound produced by the acoustic source will be received by an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system. If an ocean bottom node system is used it would consist of approximately 280 nodes covering an area of 9.95 km^2 of seabed. Additional nodes would be deployed where any infill is required along the coast. Nodes would be placed at 150 m station intervals, with a tether and weights attached to assist in retrieval following the completion of seismic acquisition.

Two vessels will be mobilised for the Turangi 3D Seismic Survey; a primary source vessel and a node/acoustic positioning vessel (termed the 'secondary vessel'). It is anticipated that the source vessel will be approximately 18 metres long with a shallow draft (c. 1.2 m). The acoustic source will be towed behind the primary source vessel, while nodal deployment and acoustic positional will be operated from the secondary vessel. The MMOs, PAM system and PAM Operators will be stationed onboard the primary source vessel.

Retrieval of the ocean bottom acquisition system will commence at the conclusion of acquisition of all source points. The duration of the marine component of this survey is weather dependant around sea state but is anticipated to be approximately three weeks (21 days) from ocean bottom acquisition system deployment to retrieval. Acquisition will take approximately seven days and will only occur during daylight hours. The survey specifications for the Turangi 3D Seismic Survey are provided in **Table 2**. It should be noted that the

Table 2 Turangi 3D Seismic Survey specifications

Parameter	Option 1 Specifications	Option 2 Specifications
Source type	Two sub arrays of three active acoustic sources per sub array (100 + 100 + 200 + 250 + 250 + 100 source units)	Two sub arrays of two acoustic sources per sub array (total of 4 x 355 in^3 source units)
Source volume	1,000 in^3	1,420 in^3
Maximum predicted output	Peak sound pressure level is modelled at 247 dB re 1 µPa @ 1m	Peak sound pressure level is modelled at 242 dB re 1 µPa @ 1m
Nominal operating pressure	2000 psi firing pressure	2000 psi firing pressure
Source Frequency	10-70 Hz	10-70 Hz
Source Depth	3 m	3 m

MMOs and PAM for the acoustic detections of marine mammals will be implemented during the survey. These are discussed in more detail in **Section 3.2**.

STLM was conducted based on the specific acoustic source volume and array configuration described here and is discussed further in **Section 6.2.2.1** and the full STLM results are attached as **Appendix A**.

2.2.1 Turangi 3D Testing Area

As part of the Turangi 3D Seismic Survey NZSL is proposing the inclusion of a 1 km x 1 km Testing Area located approximately 1.2 km north-east of New Plymouth Port (shown in **Figure 1**). The seismic team would ensure that proper acoustic source, navigation, and recording system synchronisation is verified prior to the departure to the Primary Operational Area. To accomplish this, the entire network of electronics will be verified at the Testing Area, simulated and accepted prior to acquisition commencing. During testing operations, all operational monitoring, mitigation and reporting requirements detailed in the MMMP will be met.

The Testing Area will be used for up to eight days during which time the acoustic source may be tested.

2.3 Navigational Safety

NZSL has considered the normal influx of holiday makers to the Primary Operational Area and propose that acquisition occur immediately following the summer school holidays. This will allow initial phases to be completed with minimal impact to other marine users as recreational activities, including fishing and recreational boating, will reduce at this time.

Precision real-time kinematic GPS will be used for all vessels as the primary surface positioning system. The position data will be used in conjunction with a magnetic compass with water depths obtained through the vessels single beam echo sounders or a survey grade echo sounder if required.

2.4 Survey Design Considerations and Alternatives

The two potential acoustic source array configurations and associated sound levels for the Turangi 3D Seismic Survey have been proposed to ensure sufficient power to fulfil the survey objective, whilst minimising excessive acoustic noise in the surrounding marine environment. A maximum source level of 1,420 in^3 is proposed by NZSL.

The Turangi 3D Seismic Survey will be undertaken in summer/autumn months to take advantage of settled weather. This timing not only makes for more amendable working conditions for the crew, but also serves to reduce environmental effects as follows:

- It minimises down-time due to the weather which will ensure that the duration of the survey is as short as possible, resulting in fewer effects on both the marine environment and those that use it; and
- The favourable weather generally enables better sighting conditions for MMOs to undertake visual observations.

3 Legislative Framework

The legislative framework that relates to the proposed Turangi 3D Seismic Survey is described below. Of primary relevance is the Code of Conduct, as compliance with this Code is required by the PCP and the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008 which was updated in November 2020 by the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020.

3.1 Taranaki Regional Coastal Plan

The Taranaki Regional Council (**TRC**) is working with the Environment Court and appellants regarding appeals on the PCP. The PCP introduced more stringent requirements regarding seismic surveys in the CMA than the operative Regional Coastal Plan for Taranaki 1997 and classifies seismic survey operations within the Taranaki CMA as a controlled activity under Rule 12, subject to the following conditions:

- The TRC is informed of the activity at least five working days before commencement of the operations;
- The activity complies with the Code of Conduct;
- The activity complies with the general standards in Section 8.6 (of the PCP)[1];
- The activity does not have an adverse effect on significant indigenous biodiversity, including those identified in Schedule 4 (of the PCP); and
- The activity does not have a significant adverse effect on the values associated with taonga species identified in Schedule 5 (of the PCP).

The matters of control under Rule 12, are as follows:

- Location (including any buffer distances), method, timing and notification of works;
- Effects on other authorised structures or activities;
- Effects on indigenous biodiversity values;
- Effects on cultural and historic heritage values;
- Effects on navigation;
- Effects of noise and light;
- Monitoring and information requirements;
- Duration of consent; and
- Review of consent conditions.

Species of significant indigenous biodiversity and taonga species (as identified in Schedule 4 and Schedule 5 of the PCP) are provided in **Appendix D**.

While the PCP is not yet fully operative, Rule 12 is beyond legal challenge and is therefore treated as being operative.

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[1] The only general standard of relevance is subpart 4 of Section 8.6 which refers to 'all other noise' and which has been addressed in the associated resource consent application.

3.2 Code of Conduct

The Code of Conduct was developed by DOC in consultation with a broad range of stakeholders in marine seismic survey operations in New Zealand to manage the potential impacts of seismic operations on marine mammals. Throughout the development of the Code of Conduct, DOC worked with stakeholders who participated in various working and review groups and provided submissions and contributed to the review process. Stakeholders involved in the development of the Code of Conduct include observers, researchers, operators and regulators. 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 New Zealand 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 in^3) are typically large-scale geophysical investigations, Level 2 surveys (151 – 426 in^3) are lower scale seismic investigations often associated with scientific research, and Level 3 surveys (<150 in^3) include all small-scale, low-impact, surveys. The output of both potential source arrays for the Turangi 3D Seismic Survey (i.e. 1,000 and 1,420 in^3) means that this survey is classified as a Level 1 survey. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

3.2.1 Notification

Section 3.6 of the Code of Conduct states that no person may carry out a marine seismic survey within a Marine Mammal Sanctuary unless they have notified the Director-General of Conservation of their intention to carry out the survey and submitted a written environmental impact assessment (being a MMIA). The notification and submission of the environmental impact assessment must be at least three months before commencing the survey.

NZSL provided notification to DOC on the originally proposed Turangi 3D Seismic Survey in December 2020. As this version of the proposed survey is similar in nature and location it is considered that this is sufficient to meet the three month requirement.

3.2.2 Marine Mammal Impact Assessment

To comply with the Code of Conduct when a seismic survey is acquired in a marine mammal sanctuary, a MMIA is required to be submitted to the Director General of Conservation three months prior to the commencement of the survey to:

- 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 engagement 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 engagement 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.

3.2.3 Areas of Ecological Importance and Marine Mammal Sanctuaries

Any seismic survey operation within an Area of Ecological Importance or Marine Mammal Sanctuary requires more comprehensive planning and consideration, including additional mitigation measures to be developed and implemented through the MMIA process.

The extent of the Areas 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. Where data was incomplete or absent, technical experts have helped refine the Area of Ecological Importance maps.

The Marine Mammal Protection (West Coast North Island Sanctuary) Notice 2008 which was amended in November 2020 by the Marine Mammal Protection (West Coast North Island Sanctuary) Amendment Notice 2020 established a marine mammal sanctuary which extends from Maunganui Bluff in Northland to Taputeranga Marine Reserve on the south coast of Wellington. This sanctuary is referred to as the 'West Coast North Island Marine Mammal Sanctuary' and covers all the CMA within the Taranaki Region.

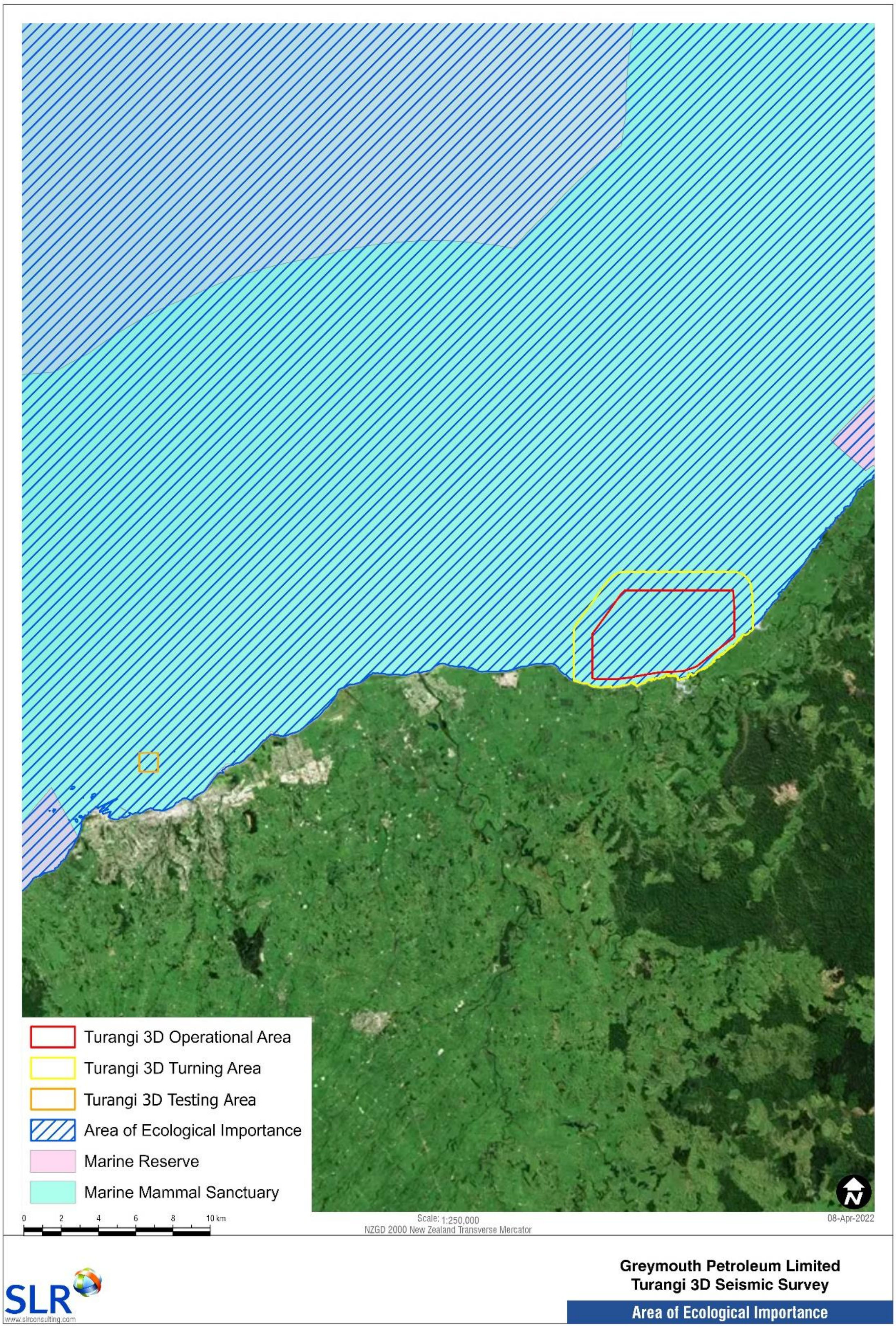
The both the Primary Operational Area and the Testing Area are located within the Area of Ecological Importance and the West Coast North Island Marine Mammal Sanctuary (**Figure 2**).

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 validate the suitability of the mitigation zones by accounting for the specific configuration of the acoustic array and the local environmental conditions (i.e. bathymetry, substrate, water temperature and underlying geology) within the modelled area. The model results indicate whether or not the standard mitigation zones outlined in the Code of Conduct are sufficient to protect marine mammals from physiological impacts during the seismic survey in accordance with the following thresholds:

- Temporary loss of hearing ability may occur if marine mammals are subject to SELs greater than 171 dB re 1 µPa^2·s. Temporary hearing loss is referred to as a 'Temporary Threshold Shift' and is discussed further in **Section 6.2.2.2.1**; and
- Permanent loss of hearing ability and other physiological injury may occur if marine mammals are subject to SELs greater than 186 dB re 1 µPa^2·s. Permanent hearing loss is referred to as a 'Permanent Threshold Shift' and is discussed further in **Section 6.2.2.2.1**.

If the STLM predicts exceedances of these thresholds at any of the modelled locations, then consideration must be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. NZSL has undertaken STLM for the Turangi 3D Seismic Survey (**Appendix A**). Results from the STLM are discussed in **Section 6.2.2.1**.

Figure 2 Relationship between the Primary Operational Area and Testing Area and Areas of Ecological Importance



3.2.4 Observer Requirements

All Level 1 seismic surveys require the use of MMOs in conjunction with PAM. MMOs visually detect marine mammals during daylight hours while the PAM system acoustically 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 Level 1 seismic survey in compliance with the Code of Conduct the minimum qualified observer requirements are:

- There will be at least two trained and qualified MMOs on-board at all times;
- There will be at least two trained and 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, two qualified MMOs (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.

In the event that qualified MMO and PAM Operator personnel are unable to be engaged, the Code of Conduct provides for a qualified MMO or PAM Operator to act as a supervisor/mentor to a trained MMO or PAM Operator. Therefore, one qualified observer and one trained observed may be engaged in each observation role (i.e. MMO or PAM Operator); however, at least one of the engaged MMOs will be qualified as there are no provisions under the Code of Conduct for a suitable trained MMO to undertake the same role as a qualified MMO. Prior to the commencement of the Turangi 3D Seismic Survey, the names, qualifications, and experience of each observer will be provided to DOC.

If observers (i.e. MMOs 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. In the event that the Director-General of Conservation determines additional measures are necessary, the MMO/PAM team in conjunction with NZSL would then immediately implement any adaptive management actions without delay.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans (i.e. Hector's/Māui's dolphin, dwarf sperm whale, and spectacled porpoise), 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 an MMO confirm the acoustic detection was of a species falling into the category of 'Other Marine Mammals' (i.e. not a Species of Concern[2]).

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:

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[2] Those species set out in Schedule 2 of the Code of Conduct.

- 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.

NZSL will contract Blue Planet Marine to provide the required MMOs and PAM Operators for the Turangi 3D Seismic Survey. Personnel and their equipment will be located onboard the source vessel. The MMOs and PAM Operators will be qualified and trained in accordance with the Code of Conduct.

MMO observations can only be made during daylight hours whereas PAM can be operational on a 24-hour basis; however, NZSL has committed to restrict acquisition to daylight hours. Details of the PAM specifications are provided in **Appendix B**.

3.2.5 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 by the qualified observers no longer than 14 days after survey completion. 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 3**.

Table 3 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 hydrophone arrays.
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticule 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 when there is a significant change in weather condition.	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, and the time and duration it was heard.
Implement appropriate mitigation actions (delayed starts and shut downs).	Implement appropriate mitigation actions (delayed starts and shut downs).
Record acoustic source power output while in operation, and any mitigation measure 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.

3.2.6 Pre-start Observations

During a Level 1 survey, the Code of Conduct stipulates that the acoustic source can only be activated if it is within the specified Operational Area/s and adheres to the following protocol:

- The acoustic source cannot be activated during daylight hours unless:
  - Two qualified MMOs have 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, and no New Zealand fur seals have been observed in the relevant mitigation zones for at least 10 minutes; and
  - PAM for the presence of marine mammals has been carried out by a trained and 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.

3.2.6.1 Start-up in a 'new location' in poor sightings conditions

There will be no night-time operations as part of the Turangi 3D Seismic Survey. As NZSL will only acquire during daylight hours, there will be a substantial (i.e. overnight) break in activation of the acoustic source. Although operations will continue the following day within the same location (i.e. within the Primary Operational Area), this overnight break meets the requirement of a 'new location' for each day of the Turangi 3D Seismic Survey. On this basis, the following additional start-up requirements will be applied to the first source activation of the day in poor sightings conditions:

- Two MMOs will have undertaken observations within 20 Nautical Miles (**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.

3.2.7 Soft Starts

A soft start consists of gradually increasing the 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 or during source testing.

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. Activation of the acoustic source at least once within sequential 10-minute periods shall be regarded as continuous operation.

3.2.8 Delayed Starts and Shutdowns

The following Code of Conduct requirements for delayed starts and shutdowns will be followed. Stricter mitigation measures have been implemented for marine mammals classified as a 'Species of Concern' (i.e. all whales and most dolphins in New Zealand) under Schedule 2 of the Code of Conduct. Species of Concern are identified in **Table 7**, with the full list provided as **Appendix C**. Marine mammals not considered a 'Species of Concern' fall under the category of 'Other Marine Mammal'.

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

If, during pre-start observations or while the acoustic source is active (including during soft starts), a qualified observer detects at least one Species of Concern with a calf within 1.5 km of the acoustic source, start-up procedures will be delayed, or the acoustic 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 acoustic source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1.5 km of the acoustic source, and the mitigation zone remains clear.

3.2.8.2 Species of Concern within a Mitigation Zone of 1 km

If during pre-start observations, or while the acoustic source is active (including during soft starts), a qualified observer detects a Species of Concern within 1 km of the source, start-up will be delayed, or the acoustic 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 km from the acoustic source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a Species of Concern within 1 km of the acoustic source, and the mitigation zone remains clear.

3.2.8.3 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 acoustic source; or
- Despite continuous observation, 10 minutes has elapsed since the last detection of a New Zealand fur seal within 200 m of the acoustic 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 have moved beyond the respective mitigation zones, and the mitigation zone has remained clear for 30 minutes, there will be no further delays to the initiation of soft start procedures.

3.3 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 seven gazetted Marine Mammal Sanctuaries along the coast of New Zealand. Additionally, one whale sanctuary and a New Zealand fur seal sanctuary were established under the Kaikōura (Te Tai o Marokura) Marine Management Act 2014 that have equivalent status to Marine Mammal Sanctuaries.

3.3.1 Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008 and Marine Mammal Protection (West Coast North Island Sanctuary) Amendment Notice 2020

Restrictions can be placed on noise-emitting surveys in Marine Mammal Sanctuaries to prevent or minimise disturbance to marine mammals. The Turangi 3D Seismic Survey is proposed to take place within the boundaries of the West Coast North Island Marine Mammal Sanctuary (**Figure 2**), on this basis NZSL must also comply with the Marine Mammal Protection (West Coast North Island Sanctuary) Notice 2008 which was amended in November 2020 by the Marine Mammal Protection (West Coast North Island Sanctuary) Amendment Notice 2020 which places specific restrictions on seismic surveys within this sanctuary.

Under clause 5 of the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008, a person must not carry out a seismic survey from a vessel in the sanctuary unless in accordance with one of several exemptions. One such exemption, under clause 5(1)(a), is under an existing permit, an existing privilege, or a subsequent permit.

The interpretation clause of the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008 defines an ‘existing permit’ as:

a. *means a mining permit, an exploration permit, or a prospecting permit that has been granted and has not expired or been surrendered or revoked on the date on which the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020 comes into force; and*

b. *includes –*

   (i) *an extension of land granted to the area of an existing permit, an existing privilege, or a subsequent permit under the applicable mining legislation after the date on which the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020 comes into force; and*

   (ii) *an authorisation granted under applicable mining legislation that allows seismic surveying outside the area of an existing permit, an existing privilege, or a subsequent permit after the date on which the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020 comes into force*

The Turangi 3D Seismic Survey will be undertaken under an existing permit, PMP 38161, including in an area outside of PMP 38161 which has been authorised under section 42A of the Crown Minerals Act 1991 (discussed further in **Section 3.4**); in addition, the Testing Area will be undertaken within PMP 50509. Therefore, the proposed survey is exempt from the prohibition under the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008.

Clause 5(3) states that a seismic survey that is exempt from the prohibition must comply with the Code of Conduct when undertaking seismic surveying in the sanctuary. The Turangi 3D Seismic Survey will operate in accordance with the Code of Conduct as described in **Section 3.2**.

3.4 Crown Minerals Act 1991

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

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. 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, 2015).

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 engagement with iwi and hapū, including the matters that must be consulted on (such as all permit applications) and the engagement principles. Engagement that was undertaken by NZSL in relation to the Turangi 3D Seismic Survey is detailed in **Section 4**.

3.5 International Regulations and Conventions

The following international regulations and conventions will be adhered to during the Turangi 3D Seismic Survey:

- International Regulations for the Prevention of Collisions at Sea 1972 (**COLREGS**); and
- International Convention for the Prevention of Pollution from Ships 1973 (**MARPOL**).

4 Stakeholder Engagement

NZSL has undertaken consultation with stakeholders and tangata whenua in relation to the Turangi 3D Seismic Survey. This consultation process involved groups being consulted in person, by telephone, or by email correspondence. All groups that NZSL consulted with for the Turangi 3D Seismic Survey are listed in **Table 4**.

Due to the location of the Primary Operational Area lying in the rohe of Ngāti Mutunga (see **Figure 13**), Ngāti Mutunga were the main engaged with by NZSL with regard to the Turangi 3D Seismic Survey. Ngāti Mutunga raised concerns regarding potential effects on little blue penguins; little blue penguins are discussed in **Section 5.2.9.1**, and potential effects from the Turangi 3D Seismic Survey on seabirds (including little blue penguins) are discussed in **Sections 6.2.1.2**, **6.2.2.2.6**, and **6.2.2.3.5**.

All relevant iwi and hapū will be sent a copy of the MMIA.

Table 4 Stakeholders and iwi groups NZSL has engaged with

DOC
11 November 2021 – Zoom call to discuss upcoming seismic surveys, requirements under the code of conduct, MMIAs, etc.
Taranaki Regional Council
15 December 2021 – Email sent advising of upcoming seismic surveys, requested a time to meet or call to discuss consent application. 21 December 2021 – Phone call to advise of upcoming seismic surveys, coastal plan, when they can expect to receive consent applications, BTW preparing applications, and iwi engagement to date/going forward.
Ngāti Mutunga
Summer 2020/2021 – NZSL engaged with Ngāti Mutunga over this summer period regarding the previous proposal for a seismic survey (which was not completed fully). The previous survey is now essentially the same as that proposed by this MMIA. 14 December 2021 – phone call to advise of upcoming survey and to try to arrange a time to meet before Christmas. Advised they are not available until the New Year. 15 December 2021 – email sent advising of upcoming survey, included map of the survey area. Requested time to meet first thing in the new year. Meeting arranged for 12 January 2022. 12 January 2022 – in-person meeting undertaken. NZSL representatives outlined the proposed seismic survey, noting it was very similar to the seismic survey that was discussed in summer 2020/2021. Requirements for MMO's were discussed. Ngāti Mutunga do not have any trained MMO's; however, Ngāti Rahiri hapu have two trained MMO's. Ngāti Mutunga support using the two MMO's from Ngāti Rahiri. Little blue penguins were discussed, which NZSL advised is covered in the MMIA. Also discussed that observations of little blue penguins will be included in daily observations and reported alongside the required marine mammal observations.
Ngāti Rahiri
Summer 2020/2021 – NZSL consulted Ngāti Rahiri around arranging MMOs for the proposed survey as suggested by Ngāti Mutunga. 17 January 2022 – in-person meeting undertaken. NZSL representatives outlined the proposed seismic survey, noting it was very similar to the seismic survey that was discussed in summer 2020/2021. Ngāti Rahiri has two trained MMO's which NZSL will use for the seismic survey.
Ngāti Te Whiti
NZSL has made various attempts (phone calls and emails) to arrange a time to meet with Ngāti Te Whiti representatives to discuss the testing area of the proposed seismic survey. Unfortunately, an in-person meeting has not occurred. NZSL continues to contact Ngāti Te Whiti with the objective of meeting to discuss the proposed seismic survey.
Others
First quarter of 2022 – NZSL plans to engage with the following (some of which has already begun in early 2022) and advise of the upcoming planned seismic surveys: • Project Jonah; • New Plymouth Sport Fishing and Underwater Club; • New Plymouth Yacht Club; • Urenui Boat Club; • Waitara Offshore Fishing Club; • Port Taranaki (Harbour Master); • Maritime New Zealand; and • Egmont Seafoods.

5 Existing Environment

The scope of this section generally covers the area from New Plymouth to Mokau River Mouth to encompass both the Primary Operational Area and the Testing Area in shown in **Figure 9**. This broader area is hereafter referred to as the Area of Interest (**AOI**) and discussed in more detail in **Section 5.2.6.1**.

5.1 Physical Environment

5.1.1 Meteorology

Due to its position on New Zealand's west coast, the Taranaki Region is exposed to all weather systems migrating over the Tasman Sea. With a predominantly westerly airstream, this region is one of the windiest in New Zealand (Chappell, 2014). The most settled weather occurs in summer and early autumn, with winter months the most unsettled time of the year (NIWA, 2021a).

Winds within the Taranaki region are largely influenced by local terrain, notably the location relative to Mount Taranaki and the central high country and the orientation of the coast. Wind direction at New Plymouth airport (approximately 15 km west of the Primary Operational Area) is predominantly from the west. Spring is generally the windiest season throughout the region, with the least strong winds observed in summer (Chappell, 2014).

Taranaki's rainfall is related to elevation and exposure to northerly to westerly winds. Westerly airstreams are associated with periods of unsettled showery weather. In these situations, a belt of high pressure lies to the north of the country, while to the south migratory depressions move steadily eastwards. The westerly airstream frequently contains rapidly moving cold fronts bringing periods of heavier showers to western New Zealand. Most of North Taranaki experiences annual rainfalls in excess of 2,000 mm per year, although due to its coastal location annual rainfall in the Primary Operational Area and Testing Area is less at approximately 1,600 mm. Rainfall maximum occurs in winter, and minimum in summer or early autumn (Chappell, 2014).

5.1.2 Currents and Waves

5.1.2.1 Currents

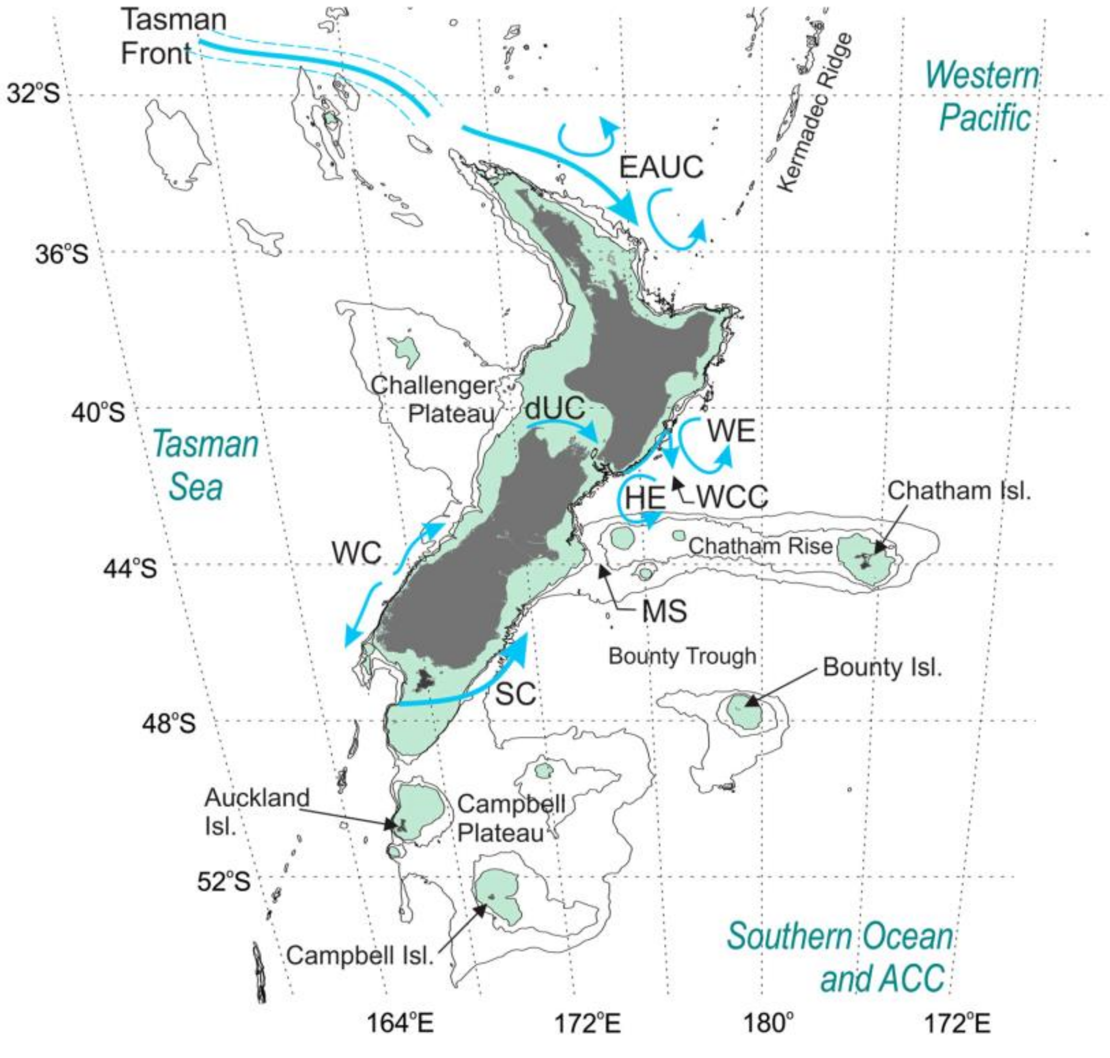
New Zealand's coastal current regime is dominated by three components: wind-driven flows, low-frequency flows and tidal currents. The net current flow is a combination of all these components and is further influenced by the local bathymetry.

New Zealand lies in the pathway of eastward-flowing currents driven by winds that blow across the South Pacific Ocean (Brodie, 1960; Te Ara, 2021a). As a result, New Zealand is 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; Te Ara, 2021a).

The main ocean currents around New Zealand are illustrated in **Figure 3**. The eastward flow out of the Tasman Sea 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). As the West Auckland Current travels south, it is met in the North Taranaki Bight by the north-flowing Westland Current. The Westland Current flows from the west coast of the South Island up to the west coast of the North Island where it weakens and becomes subject to seasonal variability. As a result of local weather conditions and seasonality, the convergence zone of the two currents is highly variable (Brodie, 1960; Ridgway, 1980; Stanton, 1973).

Seasonal variation in the West Auckland Current and Westland Current results in varying temperatures and salinity off the Taranaki coastline. During winter, the West Auckland Current extends further south, bringing warmer waters. In contrast, the West Auckland Current is weaker in the summer months and the Westland Current dominates, bringing colder waters (Ridgway, 1980; Stanton, 1973).

Figure 3 Ocean circulation around the New Zealand coastline



Note: Costal currents, plateaus and features shown including the Tasman Front, East Auckland Current (EAUC), Wairarapa Coastal Current (WCC) and Eddy (WE), Westland Current (WC), Southland Current (SC), Hikurangi Eddy (HE), Mernoo Saddle (MS), and D'Urville Current (dUC). Regions less than 250 m water depth are shaded and the 500 and 1,000 m isobaths are shown.

Source: Stevens *et al.,* 2019

5.1.2.2 Waves

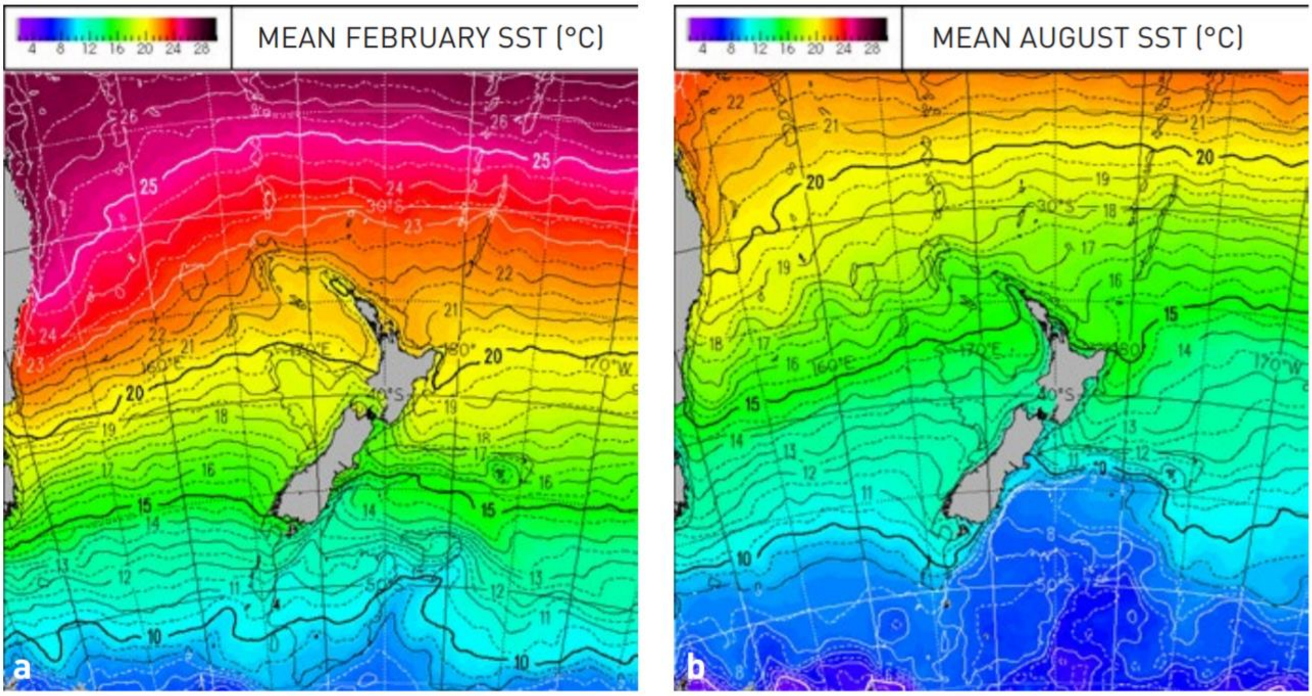
The Taranaki region is considered to have a high-energy wave climate due to its exposure to long-period swells originating from the Southern Ocean and locally generated seas (Hume *et al.*, 2015). The majority of the wave energy arrives from the west and southwest, with southerly waves able to rapidly rise. In general, wave height in the Taranaki Bight shows a seasonal cycle, with mean significant wave heights peaking in late winter and lowest in late summer (MacDiarmid *et al.*, 2015).

5.1.3 Sea Surface Temperature

Sea surface temperatures in New Zealand waters generally show a north-to-south gradient, with warmer waters being found in the north, cooling towards the south (Te Ara, 2021b).

The warmest and coolest months for sea surface temperature are February and August, respectively. Sea surface temperature in the Primary Operational Area and Testing Area ranges from approximately 12 to 20 °C (**Figure 4**). Mean sea surface temperatures in Taranaki are warmer than mean air temperatures (Chappell, 2014).

Figure 4 Monthly mean surface temperature (°C) for February (left) and August (right)



Source: As referenced in Chappell (2014)

5.1.4 Ambient Noise

Ambient noise is the sound field against which signals must be detected (Hildebrand, 2009). Within the ocean, ambient noise is generated by numerous sources, including:

- Biological – marine organisms (e.g. cetacean vocalisations and echolocations, drumming of the swim bladder by fish, snapping shrimp feeding behaviours);
- Physical – meteorological, oceanographic processes and natural seismic events (e.g. breaking waves, rain, lighting strikes, earthquakes); and
- Anthropogenic – shipping traffic, marine construction, seismic surveys, drilling.

Water depth and seabed reflectivity influences the levels of ambient noise present in the marine environment, where ambient noise levels increase with seabed reflectivity and decrease with water depth (Dahl *et al.*, 2007). As a result, deeper offshore waters, which generally have mud substrates, will have a lower ambient noise level than the shallower seabed closer to the shoreline, which generally has sandy substrates.

In 2016, the National Institute of Water and Atmospheric Research (**NIWA**) deployed seven passive acoustic monitoring devices in moorings in the greater Cook Strait region. During this study vessel noise was found to be the dominant contributor to the shallow water soundscape (i.e. < 250 m) (Giorli *et al*., 2018).

McPherson *et al*. (2019) investigated marine sound levels along coastal West Coast North Island. Vessel traffic density (and therefore noise) north of the Taranaki region was relatively low within 12 NM of the coast. Noise levels increased with increasing proximity to Port Taranaki due to higher levels of shipping traffic and the proximity of infrastructure.

Due to the low level of vessel traffic within the Primary Operational Area (see Section **5.5.2**), non-anthropogenic sources including wind, waves, and biological sources likely the main contributors to noise levels. Operations at the Pohokura Field will also have an influence on the ambient underwater noise levels experienced within this Operational Area.

5.1.5 Bathymetry and Geology

Both Operational Areas cover a near-shore section of the North Taranaki Bight. The seabed in the Primary Operational Area is relatively flat, ranging from the beach to a maximum water depth of approximately 20 m (**Figure 5**). Whereas the Testing Area is within water depth of approximately 10 m.

There are eight sedimentary basins underlying New Zealand’s continental shelf with known or potential hydrocarbons present (**Figure 6**). To date, commercial quantities of oil and gas have only been produced from the Taranaki Basin; however, non-commercial hydrocarbon discoveries have been made in the East Coast, Canterbury and Great South basins (NZP&M, 2014).

Both Operational Areas are located within the Taranaki Basin, which lies at the southern end of a rift that developed sub-parallel to the Tasman Sea rift that now separates Australia from New Zealand. The Taranaki Basin occupies the site of a late Mesozoic extension on the landward side of the Gondwana margin and covers approximately 330,000 km². The current structure of the basin is controlled by movements along the Taranaki, Cape Egmont and Turi fault zones (NZP&M, 2014).

Basement rocks in the Taranaki Basin originate from several different terranes. Crustal slabs can comprise sedimentary, plutonic and volcanic rocks. The terranes around New Zealand are grouped into the Paleozoic (540 – 300 million years ago) Western Province, and the Permian to early Cretaceous (300 – 100 million years ago) Eastern Province. At the boundary between these two provinces is a zone of volcanic arc rocks which form the western section of the Taranaki Peninsula. The Waikato coastline to the north-east is greywacke Eastern Province terrain (Morton & Miller, 1968).

Figure 5 Seabed bathymetry of the Primary Operational Area and Testing Area

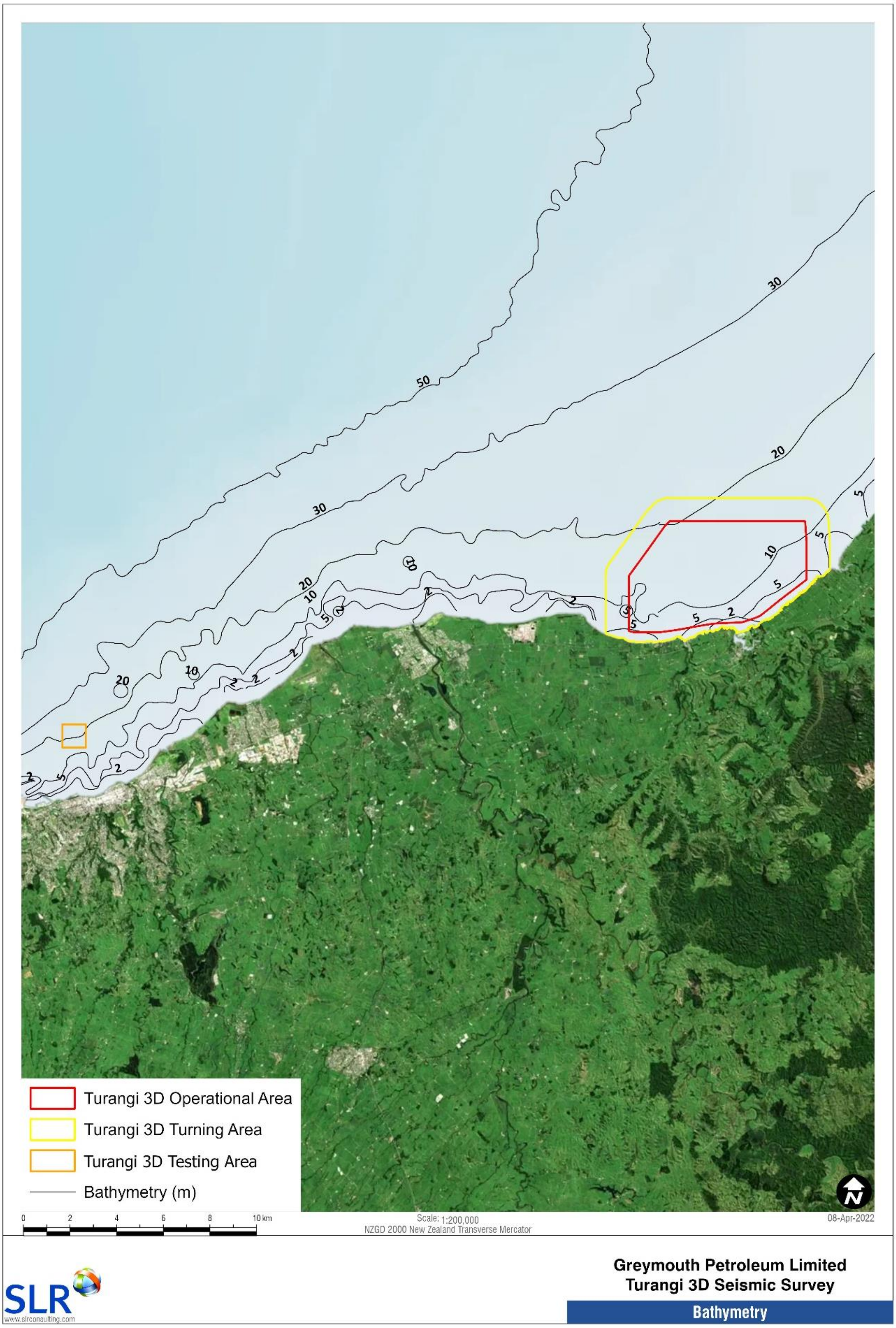


Figure 6 New Zealand's sedimentary basins

Source: NZP&M, 2014

5.2 Biological Environment

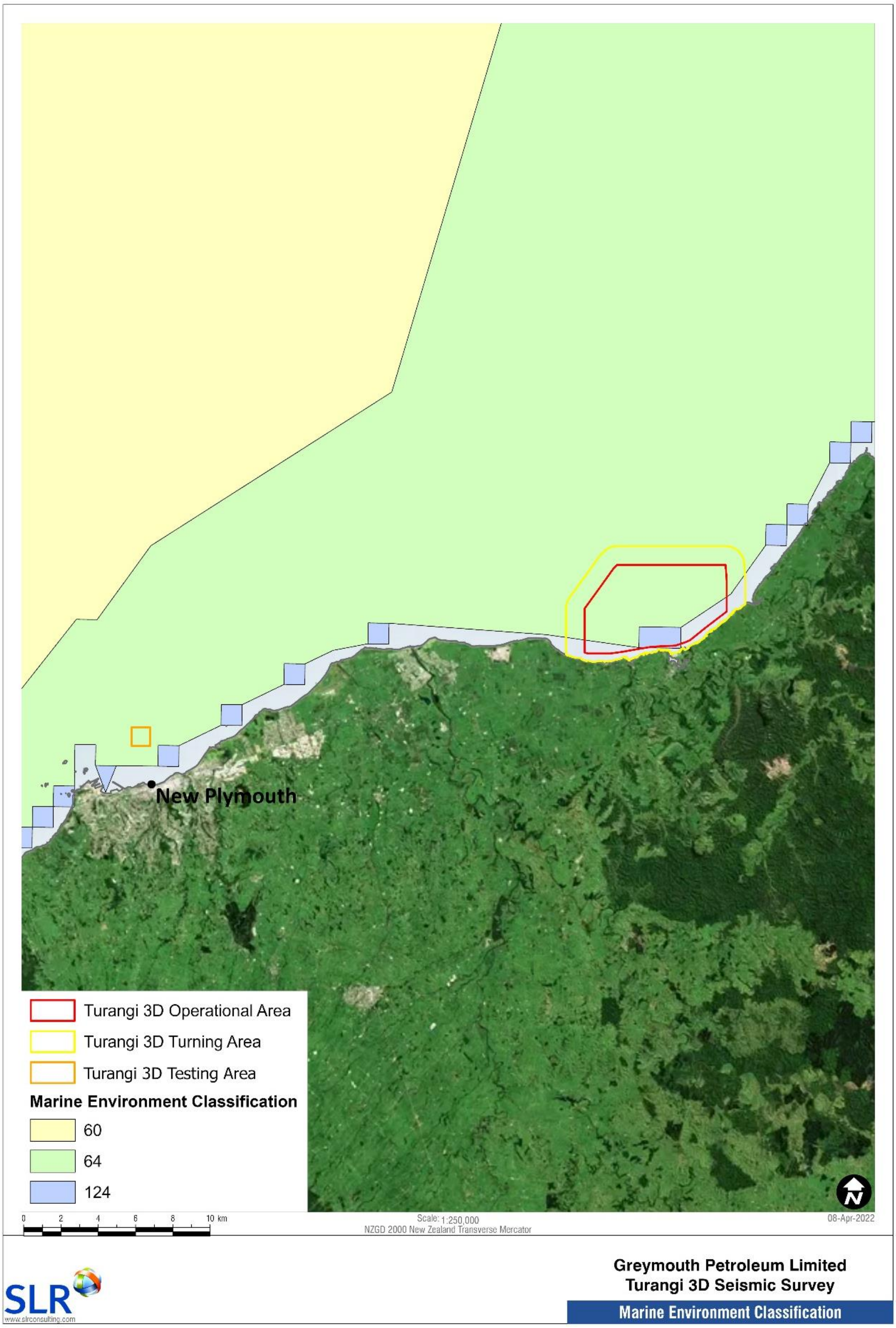
5.2.1 New Zealand Marine Environment Classification

The New Zealand Marine Environment Classification provides a spatial framework for structured and systematic management of New Zealand's CMA and EEZ. Geographic domains are divided into classes with have similar environmental and biological characters. Classes are characterised by physical and biological factors such as depth, solar radiation, sea-surface temperatures, waves, tidal current, sediment type, seabed slope and curvature (Snelder *et al.*, 2005).

According to the New Zealand Marine Environment Classification, the Primary Operational Area and Testing Area include Class 64 and Class 124 characteristics (**Figure 7**). These classifications are useful in providing a general understanding of what marine species could be present within marine regions, particularly when data is limited. These classes are described as (Snelder *et al*., 2005):

- **Class 64**: represents shallow waters (mean = 38 m). Seabed slopes are low by orbital velocities are moderately high, and the annual amplitude or sea surface temperature is high. Chlorophyll- α reaches its highest average concentration in this class. Common fish species are red gurnard, snapper, john dory, trevally, leather jacket, barracouta, and spiny dogfish. Arrow squid are frequently caught in trawls. The most commonly represented invertebrate families are Veneridae, Mactridae, and Tellinidae.
- **Class 124:** is of limited extent although is found around all of New Zealand's coastline in shallow waters (mean = 8 m) with very high orbital velocities. Commonly occurring fish include leather jacket, snapper, red gurnard, eagle ray, trevally, and john dory. The most commonly represented benthic invertebrate families are Veneridae, Mactridae, Carditidae, and Terebretellidae.

Figure 7 New Zealand Marine Environmental Classifications around the Primary Operational Area and Testing Area



5.2.2 Plankton

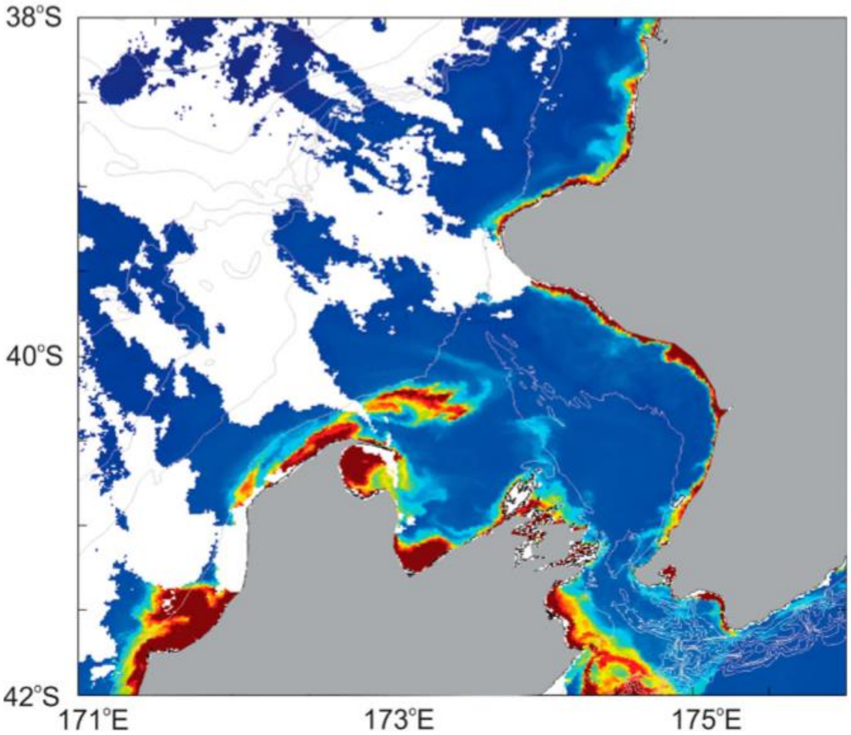
Plankton are drifting plants or animals that inhabit the pelagic zone of the world's oceans. Plankton fulfil the ocean's primary producer role and form the basis of the marine food web. Plankton have limited swimming ability and float passively with the ocean currents, which primarily controls their horizontal distribution; some can however move vertically within the water column.

There are four broad functional planktonic groups:

- Viroplankton – viral organisms in the size range of 0.02 – 0.2 µm. Viroplankton cannot survive without infecting a host;
- Bacterioplankton – bacteria that are free floating within the plankton and usually of a size range from 0.2 – 2.0 µm;
- Phytoplankton – free-floating organisms capable of photosynthesis. Includes diatoms and dinoflagellates; and
- Zooplankton – free-floating animals. Includes copepods, jellyfish and larval stages of larger animals.

Although zooplankton and phytoplankton communities in the South Taranaki Bight are well studied (with the area identified as an area of enhanced productivity (Bradford & Roberts, 1978)), communities within the North Taranaki Bight are largely un-investigated. Chlorophyll-α concentration (a measure of primary productivity) within the Primary Operational Area and Testing Area is likely to be high (see **Figure 8**) on account of nutrient inputs from various freshwater systems along the coastline (Stevens *et al*., 2019); this primary productivity will drive the coastal zooplankton community.

Figure 8 MODIS chlorophyll-α concentrations for central New Zealand



Note: Red and yellow areas indicate high chlorophyll-α estimates.

Source: Stevens *et al*. (2019)

5.2.3 Invertebrates

The TRC has undertaken six monthly State of the Environment Monitoring Programme at six representative reef sites since 1994/95. Of these six reefs, Tūrangi Reef is the most relevant to the Primary Operational Area as it is located just to the west of the Area. Invertebrate communities at Tūrangi Reef are typical of New Zealand's mid-shore, wave-exposed boulder reefs. Invertebrates identified at Tūrangi Reef during the 2015-2017 State of the Environment monitoring are listed in **Table 5**. Note that culturally important species such as paua, kina and kuku/kutae (mussels) are generally not identified as the monitored reefs are located higher on the shoreline than these species typically occur (TRC, 2017).

Hayward *et al*. (1999) carried out dredge hauls from the seafloor (water depths 6 – 22 m) approximately 0.5 – 5 km off Urenui to investigate the subtidal invertebrate communities present. The fauna present were numerically dominated by the amphipods *Heterophoxus* sp., *Photis brevicaudata, Gammaropsis* sp., and *Hippomedon hake*, and the small decapod *Ogyrides delli.* Small cumaceans were abundant within the sediments, namely *Diastylopsis elongata*, *D. teileniusi, Diastylis* spp., and *Cyclaspis* spp. The polychaete community was diverse and abundant and typical of soft sandy substrates. Common bivalves included *Nucula nitidula, Mactra ordinaria*, and *Scalpomactra scalpellum*. *Austrofusus glans* dominated the live bivalves, with *Neoguraleus amoenus, Pupa kirki,* and *Taea zelandica* also common. Other commonly occurring species were the ostracods *Leuroleberis zealandica* and *Schleroconcha* sp., and the hermit crab *Paguristes pilosus* (typically present in *Austrofusus* shells).

At 10 m water depth off Urenui, Hayward *et al*. (1999) recorded coarse shell gravel with distinctly different fauna from the soft sand substrate. Crabs were common and included live hermit crabs (*Pagurus* sp.), half crabs (*Petrolisthes novaezelandiae*) and pill-box crabs (*Halicarcinus tongi*). Three amphipods and an isopod were found in these sediments that were not recorded elsewhere in the North Taranaki Bight (Hayward *et al*., 1999).

Table 5 Invertebrates identified at Tūrangi Reef during the 2015-2017 State of the Environment monitoring

Group	Species
Polychaete worms	*Neosabellaria kaiparaensis,* scale worm spp, *Spirobranchus cariniferus, Spirorbis sp.,* Unidentified polychaete spp., large sand tubeworm.
Shrimps, crabs, isopods and amphipods	*Alope spinifrons,* Halicarcinus spp., *Heterozius rotundifrons,* Isopod spp., *Notomithrax ursus, Ozius truncatus, Pagurus spp., Palaemon affinis, Petrolisthes elongatus, Plagusia chabrus,* Amphipod spp.
Barnacles	*Austrominius modestus, Tetraclitella purpurascens, Chamaesipho columna.*
Brachiopods	Unidentified brachiopod sp.
Tunicates	Tunicate spp.
Anemones	*Isactinia olivacea*
Starfish	*Astrostole scabra, Coscinasterias muricata, Ophionerias fasciata, Patiriella regularis.*
Urchins	*Evechinus chloroticus* (kina)
Bivalves	*Protothaca crassicosta, Xenostrobus pulex*

Group	Species
Gastropods	*Buccinulum spp., Cantharidella tesselata, Cellana ornata, C. radians, Cominella maculosa, Dicathais orbita, Diloma bicanaliculata, Diloma. zelandica, Haustrum haustorium, Haustrum scobina, Jorunna sp, Margarella sp., Diloma aethiops, Notoacmea spp., Onchidella nigricans, Patelloida corticata, Scutus breviculus, Siphonaria australis, Lunella smaragda*, Zeacumantus lutelentus.
Chitons	*Acanthochitona zelandica, Chiton glaucus, Ischnochiton maorianus, Sypharochiton pelliserpentis, Sypharochiton sinclairi.*
Platyhelminthes	Flatworm spp.
Sponges	*Tethya aurantium*, UID grey sponge.
Sipuncula	Peanut worm, UID sipunculid.

Source: TRC, 2017.

5.2.4 Fish

The Primary Operational Area and Testing Area lie in the neritic zone of the ocean; the relatively shallow area that extends from the intertidal zone to the shelf break (approximately 200 m water depth). This zone supports commercially and recreationally important fish species that are generally highly mobile, do not have fixed territories, and often school, as well as species that associate with reefs and harbours for feeding (Roberts *et al.*, 2015).

Table 6 lists the fish species potentially present in the Primary Operational Area and Testing Area. The species listed in **Table 6** are based on the distribution maps provided in Roberts *et al* (2015) for New Zealand's fishes. Distribution maps are based on specimens that have been collected or sighted within and around New Zealand. Species recorded in North Taranaki in the general vicinity of the Primary Operational Area and Testing Area, and which occur in similar water depth distributions to the Primary Operational Area (i.e. intertidal out to approximately 30 m) have been included in **Table 6**. The present total (as of 2013) for the number of fish species identified within New Zealand's EEZ is 1,262 (Roberts *et al.*, 2015), therefore the table below does not provide an exhaustive list of all species present in the Primary Operational Area and Testing Area. No attempt at an assessment of likelihood of presence within the Primary Operational Area and Testing Area has been made.

Table 6 Fish species potentially present in the Primary Operational Area and Testing Area

Species – Common Name		
Basking shark	Marblefish	School shark
Banded wrasse	New Zealand sole	Seahorse
Black rockfish	New Zealand crested flounder	Shortsnout pipefish
Black goby	Northern spiny dogfish	Slender roughy
Blue mackerel	Northern bastard cod	Smooth skate
Blue warehou	Oarfish	Snake eel
Blue maomao	Olive rockfish	Southern conger
Brown topknot	Orange clinid	Spectacled triplefin
Bronze whaler shark	Orange clingfish	Spiny dogfish
Butterfly perch	Parore	Spiny seadragon
Carpet shark	Redbanded perch	Splendid perch
Common roughy	Peregrin dealfish	Spotted black grouper
Copper moki	Porbeagle shark	Spotted gurnard
Giant boarfish	Pufferfish (*Lagocephalus spp.*)	Spotty
Horse mackerel	Pōrae	Sprat
Grey brotula	Red cod	Stout rockfish
Greenbone butterfish	Red gurnard	Sweep
Jack mackerel (*T. declivis*)	Red mullet	Tarakihi
Jock stewart	Red moki	Thripenny
Kahawai	Red scorpionfish	Thornfish
Leatherjacket	Rig	Trevally
Little rockfish	Rock cod	Tiplefins (Family Tripterygiidae)
Longfin triplefin	Sandfish	Topknot
Longsnout pipefish	Scarlet wrasse	Urchin clingfish
Lumpfish	Scaly gurnard	Yelloweye mullet
Mako shark		

5.2.4.1 Freshwater Eels

Within New Zealand waters there are two main species of freshwater eel: the endemic long-finned eel (*Anguila dieffenbachii*) and the short-finned eel (*A. australis schmidtii*). A third species, the Australian longfin eel (*A. reinhardtii*), has been found in northern rivers of New Zealand and is thought to be a new arrival from Australia (Te Ara, 2021c). Long-finned eels are classified under the latest New Zealand Threat Classification System as 'Declining', short-finned eels as 'Not Threatened', and Australian longfin eels as 'Coloniser' (Dunn *et al*., 2018). Long-finned and short-finned eels are commercially harvested and managed under New Zealand's Quota Management System (Jellyman, 2012).

Although considered a freshwater species, long-finned and short-finned eels have a catadromous life history and carry out oceanic spawning at great distances from their typical freshwater habitat (Jellyman, 2012). Little is known of the marine component of their life cycle; however, three distinct migrations have been observed in New Zealand:

- Elvers (juvenile two-year-old eels) move from the marine environment into freshwater habitats from October to December. The elvers move at night, during floods, or on overcast days (Jellyman, 1977) during which time they find suitable cover and feeding grounds in the lower reaches of streams where they remain for the next four to five years (Cairns, 1950);
- Following the influx of the elvers, the four- to five-year-old eels begin an upstream migration, with this migration occurring in January (Cairns, 1950); and
- The third migration involves the movement of sexually mature adult eels (known to Māori as tuna heke or tuna whakaheke) to spawning grounds. This migration occurs in February and March, with the majority of eels having migrated by April. It has been suggested that the movement of sexually mature adult eels is influenced by the lunar cycle (Cairns, 1950; Todd, 1981). Mature females begin by moving to brackish waters where they join the mature males. First to enter the sea are short-finned males followed by short-finned females (Cairns, 1950; Todd, 1981). Long-finned eels show a similar pattern with their migrations occurring after that of the short-finned eel (Cairns, 1950; Todd, 1981). The adults move to the sub-tropical Pacific Ocean and although the exact location and migration route is not known (as eel spawning has never been observed), deep ocean trenches near Fiji and New Caledonia are thought to be important spawning grounds (NIWA, 2021b). Short-finned and long-finned eels are semelparous; that is they breed only once at the end of their life (NIWA, 2021b), resulting in no southern migration of adults returning to New Zealand.

A fourth, unobserved migration occurs which involves the southern migration of leptocephalus young (transparent leaf-shaped eel larvae) to New Zealand waters. The leptocephalii reach New Zealand waters by drifting on ocean currents. Once reaching New Zealand coastal waters they morph into eel-shaped 'glass eels' and move into river mouths and estuaries (Te Ara, 2021c) where they are generally sedentary for the first year (Jellyman, 1977). Following a year spent in river mouths and estuaries the glass eels commence their freshwater life cycle as elvers (see first point).

Adult and juvenile long-finned and short-finned eels are expected to use the waters of the Taranaki CMA during migrations, based on their known presence in Taranaki rivers (TRC, 2016).

5.2.4.2 Protected Species

There are nine species of fish listed as protected under Schedule 7A of the Wildlife Act 1953: basking shark, deepwater nurse shark, white shark, manta ray, oceanic white-tip shark, spiny-tailed devil ray, spotted black grouper, giant grouper, and whale shark. The white, basking and oceanic white-tip sharks are also protected under the Fisheries Act, prohibiting New Zealand flagged vessels from taking these species from all waters, including beyond New Zealand's EEZ. Of these protected species, the white shark and basking shark have the greatest potential to occur in the Primary Operational Area and Testing Area, with the remaining species preferring warmer waters found further north.

The New Zealand Threat Classification System considers white sharks to be 'Nationally Endangered' (Duffy *et al*., 2018). Recent genetic analysis suggests the white shark population from eastern Australia and New Zealand are a single population with a total abundance of approximately 280 – 650 adults (Hillary *et al*., 2018). White sharks occur widely throughout New Zealand waters, from the subtropical Kermadec Islands to the sub Antarctic Campbell Island (Francis *et al*., 2015). Although little is known of their New Zealand habitat use, juveniles and adults are known to occur in shallow coastal waters such as large harbours and estuaries where they feed on fish (DOC, 2021a). Sub-adults and adults also utilise waters of the open ocean and around offshore islands and banks. Once the sharks reach approximately 3 m in length, they begin to also feed on marine mammal (DOC, 2021a), and as such, subadult and adult sharks tend to aggregate near seal colonies, although major aggregation sites are only known in southern New Zealand and at the Chatham Islands.

White sharks are relatively common along New Zealand's northwest coast (Duffy *et al*., 2012) and sightings of white sharks in Taranaki waters are not rare with sharks recorded along the Taranaki coast throughout most of the year (C. Duffy in RNZ, 2019). A large (5 – 6 m) female white shark nicknamed the 'Taranaki Terror' or 'Mrs White' was first sighted in Taranaki waters in 2004 and was regularly sighted for several years around areas such as the Sugar Loaf Islands. Sightings of a large white shark off the New Plymouth breakwater in 2016 suggested that the 'Taranaki Terror' continues to use Taranaki waters, or is not the only large white shark to occur in the region (Reive, 2016). More recently, in July 2020 a 2.8 m juvenile white shark was accidentally netted off New Plymouth (Keith, 2020).

Sightings of basking sharks have been made around New Plymouth, with these sightings occurring within a few kilometres of the coast during spring and summer. These records are suggested to indicate an increase in abundance in inshore waters during warmer seasons (Francis & Duffy, 2002).

5.2.5 Cephalopods

Four groups of cephalopods are represented in New Zealand waters: squid, octopus, vampire squid, and cuttlefish. Cephalopods are an invaluable food source for several seabirds, marine mammals and fish predators. They are typically short-lived, fast growing and only spawn once before dying (MFish, 2008).

There are 42 octopus species recognised from New Zealand waters, of these, 68% are endemic (O'Shea, 2013). Octopuses are often affiliated with reef habitats and as a result are likely to be present within or in the vicinity of the Primary Operational Area and Testing Area where appropriate rough ground occurs. For example, the midget octopus, *Octopus huttoni,* is found throughout New Zealand in the intertidal and subtidal to depths of 250 m and as such may occur in the Primary Operational Area and Testing Area.

New Zealand has a diverse assemblage of squid, vampire squid, and cuttlefish with more than 85 species recorded (Te Ara, 2021d); most of these species are pelagic and inhabit open water habitats.

5.2.6 Cetaceans

Toothed whales (suborder Odontoceti) and baleen whales (suborder Mysticeti) comprise the 48 cetacean species that have been recorded in New Zealand waters (Baker *et al.*, 2019).

Baleen whales are characterised by the presence of plates of baleen in the mouth and occur throughout the world in a range of habitats from coastal areas out to deep pelagic waters (Clapham *et al.*, 1999). Most undertake large seasonal migrations between high-latitude summer feeding grounds and winter mating and calving areas in warmer, low-latitude waters. While migration routes vary between species, high mobility and movements across international boundaries is a general feature (Clapham *et al.*, 1999). The annual migrations of most species of baleen whale in the southern hemisphere are somewhat predictable; whales travel south in spring to feed in Antarctic waters over summer, returning north to temperate and tropical breeding grounds in autumn and winter (DOC, 2007). In New Zealand waters, Bryde's and pygmy blue whales are an exception as they do not exhibit clear migratory patterns and instead are considered resident or semi-resident to particular habitats or areas.

Toothed whales have teeth instead of baleen and use specialised echolocation to assist prey capture. They are found across a range of habitats and in all oceans (Hooker, 2009), and unlike the baleen whales, do not carry out large migrations; instead, most species tend to remain resident to an area (Berkenbusch *et al.*, 2013). The toothed whale assemblage in New Zealand ranges from large deep-diving sperm whales to smaller social dolphins (Berkenbusch *et al.*, 2013).

The sections below summarise which cetacean species could be present in and around the Primary Operational Area and Testing Area.

5.2.6.1 Cetacean Species that could be Present

Multiple data sources must be assessed when considering cetacean distribution in any one location. This is because ecological research on cetaceans is notoriously difficult and expensive (due to large home ranges and extended periods of time cetaceans spend submerged); therefore, knowledge of cetacean distribution is typically amassed over long temporal periods using a combination of data collection techniques (e.g. stranding data, opportunistic sightings, systematic survey data and published literature). Multiple data sources have been used to predict which cetacean species may be present within the region of the proposed operations. The data sources utilised for this assessment included:

- Sightings data (received from H. Hendriks, DOC 28/09/2021):
    - From previous seismic surveys that have been undertaken in the Taranaki region (obtained from DOC marine mammals sightings database);
    - From opportunistic sightings (obtained from DOC marine mammals sightings database);
    - From operator work vessels (obtained from the DOC marine mammal sightings database);
- Stranding data (obtained from the DOC marine mammals stranding database as received from H. Hendriks, DOC 28/09/2021)[3]; and
- Knowledge of seasonal migration patterns, general ecology and habitat preferences for each species (obtained from published literature).

Despite these data sources representing the best possible information, it is important to exercise some caution when interpreting results as:

1. High abundances of sightings are frequently associated with marine seismic surveys and petroleum wells and production facilities, where dedicated and experienced cetacean observers and acoustic monitoring tools provide high-quality data to the DOC marine mammal sightings database;
2. Gaps in sighting data do not necessarily indicate an absence of cetaceans, but typically reflect a lack of observation effort; and
3. Although stranding data provides a broad indication of species occurrence, dead animals can wash ashore well away from where they died due to ocean currents and weather patterns and sick or diseased animals may be outside their normal distributional range prior to their death.

Previous assessments of marine mammal distribution off the Taranaki coastline note that the area is well used by many marine mammal species with extensive home ranges. For this reason, it was considered that undertaking a marine mammal analysis on the small Testing Area (shown in **Figure 1**) would be inappropriate as it would most certainly lead to an under-estimate of the species that could potentially be present. On this basis a more extensive marine mammal AOI was used to describe the marine mammal species potentially affected as shown in **Figure 9**. The AOI includes all waters inshore of the CMA boundary between Oakura River mouth and Mokau River mouth.

Figure 9 provides a summary of all sightings recorded in the DOC marine mammal sightings database in the marine mammal AOI. **Figure 10** provides a summary of the DOC stranding records along this coastline.

After reviewing all the relevant ecological information that was accessible at the time of writing this MMIA, the likelihood of each marine mammal species being present in the AOI was determined as ‘likely’, ‘possible’, or ‘unlikely’. A summary of the assessment findings is presented in **Table 7**, and the following subsections provide a basic ecological summary for those species represented in the stranding or sighting database for the AOI; and our justification with regards to the likelihood determinations. **Table 7** also identifies the International Union for Conservation of Nature’s (**IUCN**) conservation status of each marine mammal.

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[3] Note that although supplied in September 2021, this database was last updated by DOC on 09/09/2020.

Figure 9 Cetacean sightings within the AOI

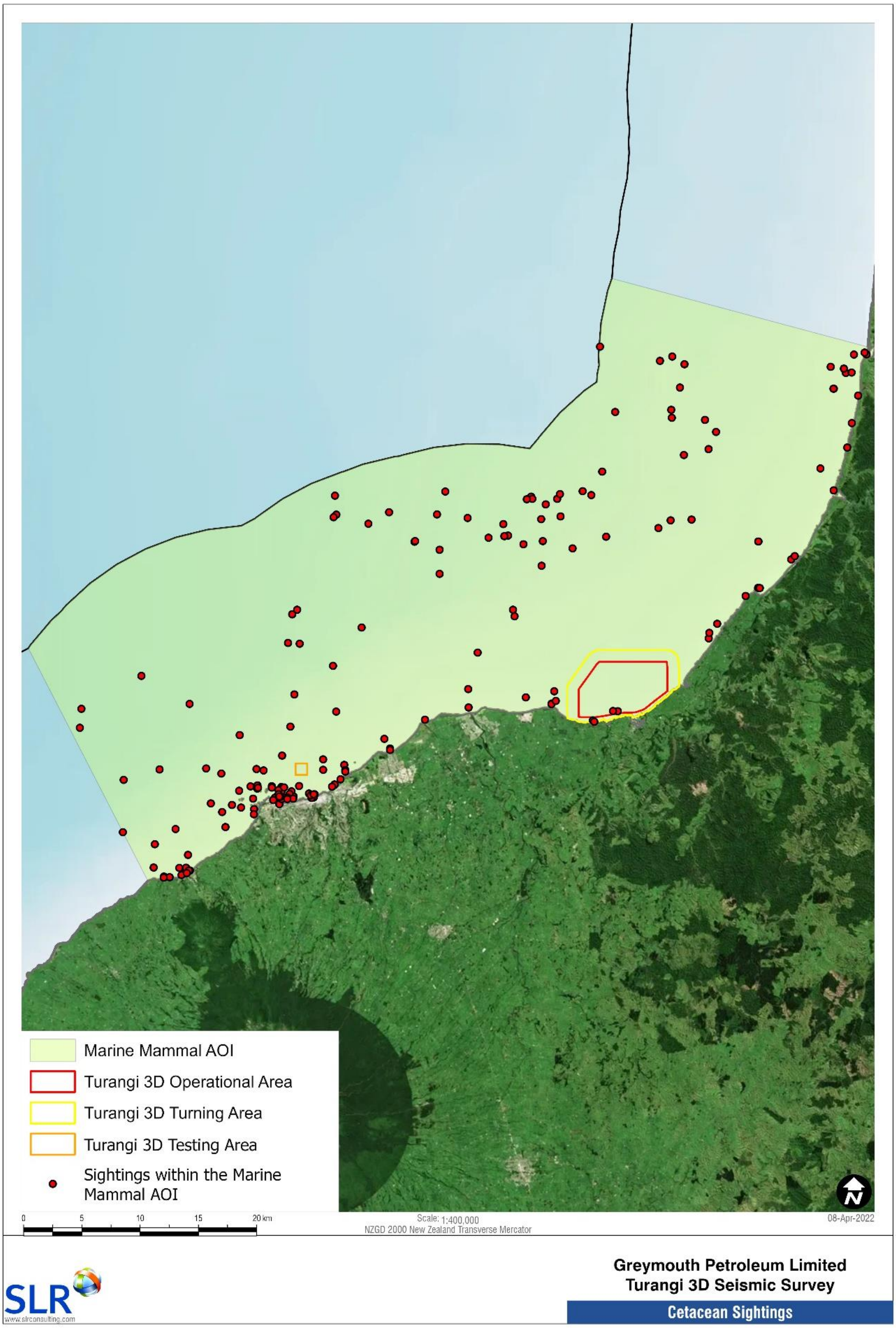


Figure 10 Cetacean stranding events within the AOI

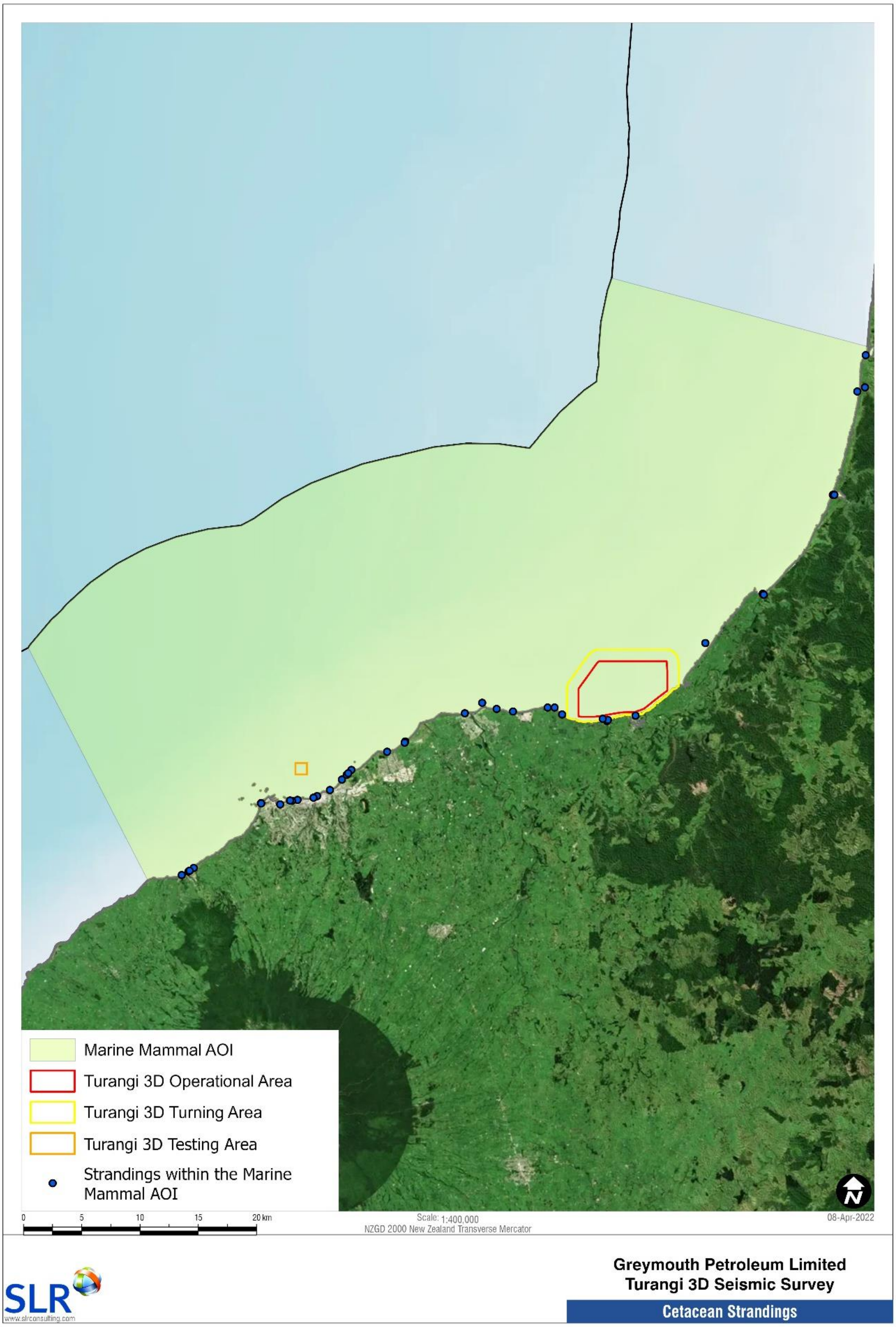


Table 7 New Zealand marine mammals and their likelihood of occurrence within the AOI

Common Name	Scientific Name	New Zealand Conservation Status (Baker *et al.*, 2019)	Qualifier *	IUCN Conservation Status www.redlist.org	Species of Concern (DOC, 2013)	DOC Stranding database (No. of events inshore of AOI)	DOC Sightings database (No. of reports in Marine Mammal AOI)	Likelihood of Presence in the Primary Operational Area and Testing Area
Andrew's beaked whale	*Mesoplodon bowdoini*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Antarctic blue whale	*Balaenoptera musculus intermedia*	Data deficient	TO	Critically endangered	✓	×	×	Unlikely
Antarctic fur seal	*Arctocephalus gazella*	Vagrant	SO	Least Concern	×	×	×	Unlikely
Antarctic minke whale	*Balaenoptera bonaerensis*	Data deficient	DP, SO	Data deficient	✓	×	×	Unlikely
Arnoux's beaked whale	*Berardius arnuxii*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Blainville's/Dense beaked whale	*Mesoplodon densirostris*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Bottlenose dolphin	*Tursiops truncatus*	Nationally endangered	De, PF, SO, Sp	Least concern	✓	×	×	Unlikely
Bryde's whale	*Balaenoptera edeni*	Nationally critical	CD, DP, SO	Data deficient	✓	1	×	Unlikely
Common dolphin	*Delphinus delphis*	Not threatened	DP,SO	Least concern	×	15	86	**Likely**
Crab eater seal	*Lobodon carcinophaga*	Vagrant	SO	Least concern	×	×	×	Unlikely
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	SO	Least concern	✓	2	×	**Possible**
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	S?O	Data deficient	×	2	1	**Possible**
Dwarf minke whale	*Balaenoptera acutorostrata*	Data deficient	DP, SO	Least concern	✓	×	×	Unlikely
Dwarf sperm whale	*Kogia sima*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
False killer whale	*Pseudorca crassidens*	Naturally uncommon	DP, T?O	Data deficient	✓	×	×	Unlikely
Fin whale	*Balaenoptera physalus*	Data deficient	TO	Endangered	✓	1	×	Unlikely
Fraser's dolphin	*Lagenodelphis hosei*	Data deficient	SO	Least concern	×	×	×	Unlikely
Gingko-toothed whale	*Mesoplodon ginkgodens*	Data deficient	S?O	Data deficient	✓	1	×	Unlikely
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	S?O	Data deficient	✓	3	×	**Possible**
Hector's beaked whale	*Mesoplodon hectori*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Hector's dolphin	*Cephalorhynchus hectori hectori*	Nationally vulnerable	CD, DP, PF	Endangered	✓	×	3	**Possible**
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	SO	Least concern	×	×	×	Unlikely
Humpback whale	*Megaptera novaeangliae*	Migrant	SO	Least concern	✓	4	19	**Possible**
Killer whale	*Orcinus orca*	Nationally critical	DP, S?O, Sp	Data deficient	✓	×	41	**Likely**
Leopard seal	*Hydrurga leptonyx*	Naturally uncommon	De, SO	Least concern	×	×	×	Unlikely
Lesser/pygmy beaked whale	*Mesoplodon peruvianus*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Long-finned pilot whale	*Globicephala melas*	Not threatened	DP, S?O	Data deficient	✓	2	1	**Possible**
Māui's dolphin	*Cephalorhynchus hectori maui*	Nationally critical	CD	Not assessed	✓	11	62	**Possible**
Melon-headed whale	*Peponocephala electra*	Vagrant	SO	Least concern	✓	×	×	Unlikely
New Zealand sea lion	*Phocarctos hookeri*	Nationally vulnerable	CD, RR	Endangered	✓	×	×	Unlikely
New Zealand fur seal	*Arctocephalus forsteri*	Not threatened	Inc, SO	Least Concern	×	3	5	**Likely**
Pantropical spotted dolphin	*Stenella attenuata*	Vagrant	SO	Least concern	×	×	×	Unlikely
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Data deficient	S?O	Data deficient	✓	×	4**	**Possible**
Pygmy killer whale	*Feresa attenuata*	Vagrant	DP, S?O	Data deficient	✓	×	×	Unlikely
Pygmy right whale	*Caperea marginata*	Data deficient	S?O	Data deficient	✓	2	×	**Possible**
Pygmy sperm whale	*Kogia breviceps*	Data deficient	DP, S?O	Data deficient	✓	1	×	Unlikely
Risso's dolphin	*Grampus griseus*	Data deficient	SO	Least concern	×	×	×	Unlikely
Ross seal	*Ommatophoca rossii*	Vagrant	SO	Least concern	×	×	×	Unlikely
Rough-toothed dolphin	*Steno bredanensis*	Data deficient	SO	Least concern	×	1	×	Unlikely

Common Name	Scientific Name	New Zealand Conservation Status (Baker *et al.*, 2019)	Qualifier *	IUCN Conservation Status www.redlist.org	Species of Concern (DOC, 2013)	DOC Stranding database (No. of events inshore of AOI)	DOC Sightings database (No. of reports in Marine Mammal AOI)	Likelihood of Presence in the Primary Operational Area and Testing Area
Sei whale	*Balaenoptera borealis*	Data deficient	TO	Endangered	✓	×	×	Unlikely
Shepherd's beaked whale	*Tasmacetus shepherdi*	Data deficient	SO	Data deficient	✓	2	1	**Possible**
Short-finned pilot whale	*Globicephala macrorhynchus*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	SO	Least concern	✓	×	×	Unlikely
Southern elephant seal	*Mirounga leonina*	Nationally critical	RR, SO	Least concern	×	×	×	Unlikely
Southern right whale	*Eubalaena australis*	Recovering	OL, RR, SO	Least concern	✓	1	23	**Likely**
Southern right whale dolphin	*Lissodelphis peronii*	Data deficient	DP,S?O	Data deficient	✓	×	×	Unlikely
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	S?O	Data deficient	×	×	×	Unlikely
Spectacled porpoise	*Phocoena dioptrica*	Data deficient	S?O	Data deficient	×	×	×	Unlikely
Sperm whale	*Physeter macrocephalus*	Data deficient	DP, TO	Vulnerable	✓	6	×	**Possible**
Strap-toothed whale	*Mesoplodon layardii*	Data deficient	S?O	Data deficient	✓	2	×	**Possible**
Striped dolphin	*Stenella coeruleoalba*	Data deficient	SO	Least concern	×	×	×	Unlikely
Subantarctic fur seal	*Arctocephalus tropicalis*	Vagrant	SO	Least concern	×	×	×	Unlikely
True's beaked whale	*Mesoplodon mirus*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Weddell seal	*Leptonychotes weddelli*	Vagrant	SO	Least concern	×	×	×	Unlikely

* Qualifiers to the New Zealand Threat Classification System are as follows: Secure Overseas (SO), Uncertain whether the taxon is secure overseas (S?O), Threatened Overseas (TO), Data Poor (DP), Conservation Dependent (CD), Sparse (Sp), Range Restricted (RR), Increasing (Inc), One Location (OL), Designated (De), Population Fragmentation (PF)

** These sightings are entered as 'blue whales' in the DOC Sightings Database; for the purposes of this MMIA, it is assumed they are pygmy blue whales based on the presence of a semi-resident population in nearby waters (South Taranaki Bight)

5.2.6.2 Baleen Whales (suborder Mysticeti)

Southern right whale (*Eubalaena australis*)

Southern right whales exhibit a seasonal distribution, spending summer months feeding in latitudes between 40 and 50°S (Oshumi & Kasamatsu, 1986) and winter months breeding in more temperate coastal habitat. Their migratory routes span thousands of kilometres, and encompass a range of habitats, from sheltered coastal wintering grounds to offshore summer feeding grounds (Carroll *et al*., 2011). While summer distribution at feeding grounds is likely linked to the distribution of prey (Tormosov *et al*., 1998), maternally directed learning of migratory destinations is evident in this species (Jackson *et al*., 2016).

Southern right whales originally occupied bays and inlets around mainland New Zealand during their winter breeding season (Bannister, 1986; Dawbin, 1986); however, commercial whaling reduced numbers around New Zealand to near extinction and no whales were seen around the mainland between 1928 and 1963 following the cessation of commercial operations (Gaskin, 1963). Capture-recapture data (photo-identification and genetics) now suggests that the New Zealand population is recovering (Carroll *et al*., 2015) and although Port Ross in the subantarctic Auckland Islands supports the densest New Zealand breeding aggregation (Rayment *et al*., 2012), recent evidence suggests a gradual recolonisation of breeding range around mainland New Zealand (Patenaude, 2003; Carroll *et al*., 2014; Carroll *et al*., 2015).

Southern right whales produce low-frequency social sounds including stereotyped upcalls used as contact calls and other tonal sounds for mate attraction (Parks & Tyack, 2005). Such vocalisations range in frequency from 50 – 600 Hz (Parks *et al*., 2007; 2011) at sound levels from 172 – 187 dB re 1 µPa @1 m (as referenced in Erbe, 2002).

Southern right whales have been sighted within the AOI on 23 occasions and one southern right whale stranding has been reported inshore. While southern right whales are **likely** to use nearshore coastal waters of the AOI during the winter breeding season, the Turangi 3D Seismic Survey will occur during summer months when this species is expected to be feeding at high latitudes. Based on this, it is **unlikely** that southern right whales will be present in the AOI during the proposed seismic operations period.

Pygmy blue whale (*Balaenoptera musculus brevicauda*)

New Zealand waters support a population of pygmy blue whales that are thought to be largely resident to the region (Barlow *et al*., 2018). While sightings reports occur across many regions of New Zealand, sightings are concentrated in the South Taranaki Bight (see Figure 3 of Barlow *et al*. 2018), leading researchers to conclude that this is as “an important area for blue whales within the New Zealand EEZ, particularly for foraging” (Barlow *et al*., 2018). Visual sightings records and acoustic detections reveal that blue whales are present in every month of the year, both off Taranaki and more widely around New Zealand (Torres *et al.*, 2017; Olson *et al.*, 2008; Barlow *et al*. 2018). This consistency of presence, coupled with genetic data that suggests a high degree of genetic isolation and a lack of international photo -identification matches, indicates that the New Zealand population is largely resident to New Zealand waters. Using mark-recapture data Barlow *et al*. (2018) produced a conservative abundance estimate for the New Zealand population of pygmy blue whales of 718 (SD = 433) individuals.

Data collected since 2012 has identified the South Taranaki Bight as a blue whale foraging ground, with data suggesting whales target the krill *Nyctiphanes australis*. The absolute distribution of blue whales in the region varies with oceanographic patterns and the subsequent distribution of prey. In El Nino conditions whales tend to be located west of the Bight, but inside the Bight during more typical weather patterns (Torres & Klinck 2016). Most sightings records of blue whales around Taranaki occur beyond the 12 NM CMA boundary (see Figure 16 in Torres *et al.,* 2017). In February 2016, a field survey gathered the first evidence of breeding behaviour in the waters within and to the west of the South Taranaki Bight. High densities of mother/calf pairs were observed, and documentation included the first aerial footage of blue whale nursing behaviour (Torres & Klinck 2016).

The IUCN Red List of Threatened Species currently lists the pygmy blue whale as ‘Data Deficient’. In the latest DOC threat assessment for marine mammals, the threat classifications for pygmy blue whales was changed from ‘Migrant’ to ‘Data Deficient’ (Baker *et al*., 2019) given the recent evidence of population residency around New Zealand. Due to the lack of availability of population trend data, a ‘Data Deficient’ classification was considered the most appropriate for this subspecies (Baker *et al*., 2019).

Krill make up the majority of the diet of blue whales, which they capture via lunge feeding at the surface or to depths of 100 m. Feeding bouts typically last 10 – 20 minutes, although blue whales are capable of carrying out dives to depths of up to 500 m that last for as long as 50 minutes (Todd, 2014). Large aggregations of prey are particularly important to the maintenance and distribution of these whales on account of this species having the highest prey demand of any predator (DOC, 2007). Aggregations of blue whales are known to occur in areas of high prey concentrations that coincide with upwelling zones (Fiedler *et al.*, 1998; Burtenshaw *et al.*, 2004; Croll *et al.*, 2005; Gill *et al.*, 2011) and it is thought that this is the reason for the concentrations of blue whales in the South Taranaki Bight (Torres *et al.*, 2017).

A recent tagging study carried out by DOC, NIWA, and Blue Plant Marine tagged two adult blue whales in order to track their movements around New Zealand. Due to the warmer waters present, the Kahurangi upwelling system was absent, and no whales were located in the South Taranaki Bight. The tagged whales were instead located 20 – 30 NM offshore from Westport where they were found to be feeding at depth in the Hokitika Canyon. Only one of the tagged whales moved north along the North Island’s west coast and through the Taranaki Bight. The second whale’s movements were tracked through Cook Strait, south along the South Island’s east coast to just off Stewart Island, then north along the west Coast to the Gilbert Seamount (approximately 550 km west of Milford Sound). Both tagged animals are thought to be pygmy blue whales (Goetz *et al*., 2021).

Blue whales vocalise at a low frequency (average of 0.01 – 0.110 kHz) (McDonald *et al.*, 2001; Miller *et al.*, 2014), meaning that their calls travel hundreds of kilometres underwater. Vocalisations of pygmy blue whales have been characterised as songs of either two or three repeating tonal sounds with harmonics (Gavrilov *et al.,* 2011). The most intense tonal sounds have been recorded to have a source level of 179 ±2 dB re 1 µPa @ 1 m. Weaker short-duration calls of impulsive down-swept sounds were estimated to have source levels of 168 – 179 dB re 1 µPa @ 1 m (Gavrilov *et al.,* 2011).

While in general there have been a high number of blue whale sightings reports from Taranaki waters (particularly the South Taranaki Bight), the majority of these occur in waters beyond the CMA. In keeping with this, only four blue whale sightings have been reported from within the AOI, and no stranding events have been documented along the coastline. Based on this information, it is **possible** that blue whales could occasionally be present in the AOI but are **unlikely** to be present in the shallow inshore Operational Areas of the Turangi 3D Seismic Survey.

Bryde's whale (*Balaenoptera edeni*)

Bryde's whales have a broad distribution throughout temperate and tropical waters of the Pacific, Indian and Atlantic Oceans. They differ from other large baleen whales in that they do not undertake seasonal migrations, and instead remain in waters 15 – 20°C between 40°N and 40°S (Yoshida & Kato, 1999; Best, 2001). Bryde's whales in temperate waters are thought to be semi-migratory and make local seasonal movements (Gaskin, 1963) to take advantage of prey aggregations (Kato, 2002; Reikkola, 2013; Carroll *et al*., 2019).

On account of their preference for warmer waters, Bryde's whales in New Zealand are mostly reported from around the North Island, particularly the north-eastern coastal region between East Cape and North Cape (Gaskin, 1963). Indeed, there are few places where Bryde's whales are frequently seen, with the Hauraki Gulf and Northland supporting one of the few recognised resident or semi-resident populations in the world (Constantine *et al*., 2015). However, it is likely that this population is part of a larger (but unknown) regional population (Baker *et al*., 2010).

Oleson *et al*. (2003) analysed Bryde's whale calls from the Eastern Tropical Pacific, the Caribbean, and the Northwest Pacific. Whilst they concluded that regional variations in calls were present, Bryde's whales typically produce low frequency 'tonal' and 'swept' calls that are not dissimilar to other baleen whales. Virtually all calls analysed had a fundamental frequency below 60 Hz and were produced in extended sequences (Oleson *et al.*, 2003).

No Bryde's whale sightings have been reported from within the AOI, and only one stranding event has been reported along this stretch of coast. Hence, Bryde's whales are **unlikely** to be present in the AOI. The coastal population concentration for this species occurs further north (Hauraki Gulf to Northland).

Fin whale (*Balaenoptera physalus*)

After blue whales, fin whales are the second largest species of cetacean (Dawson, 1985). Like most baleen whales, fin whales carry out migrations, moving to lower latitudes in winter for breeding.

The diet of fin whales varies with location. In the Southern Hemisphere their diet is dominated by krill, whereas elsewhere they consume a range of prey including fish, squid, krill, and other crustaceans (Miyashita *et al.*, 1995; Shirihai & Jarrett, 2006). Krill aggregations in the South Taranaki Bight may be significant for feeding fin whales (Torres, 2012).

Fin whale communication vocalisations have been described as short (<1 second) down-swept tones, between 28 and 15 Hz at source levels of 189 ± 4 dB re 1 µPa @1 m (Širović *et al*., 2007).

No sightings of fin whales have been reported from within the AOI, and only one stranding event has been reported along this stretch of coast. Hence, fin whales are **unlikely** to be present in the AOI during the Turangi 3D Seismic Survey.

Humpback whale (*Megaptera novaeangliae*)

Humpback whales are distributed throughout the North Atlantic, North Pacific, and Southern Hemisphere (Gibbs & Childerhouse, 2000) and undertake the longest migration of any mammal (Jackson *et al.*, 2014), feeding in the circumpolar waters of the Antarctic in summer and migrating to breeding grounds in sub-tropical or tropical waters in winter (Dawbin, 1986). Migrating whales typically use continental shelf waters (Jefferson *et al.,* 2008) and can approach closely to shore when passing headlands or moving through confined waters (e.g. Gibbs *et al.*, 2017).

Humpback whale migration routes along the coast of New Zealand were first described by Dawbin (1986) with later descriptions by Gibbs and Childerhouse (2000) confirming a similar pattern. When migrating north the majority of whales move up the South Island's east coast towards Cook Strait. Here, the migration route splits with most whales passing through Cook Strait and up the North Island's west coast, with some individuals continuing north along the North Island's east coast (Gibbs & Childerhouse, 2000). The northward migration occurs from late May to early August (Dawbin, 1986). Although the breeding grounds of humpbacks that migrate past New Zealand have not been clearly identified, a number of studies have linked New Zealand humpbacks to breeding grounds in New Caledonia, Fiji and Tonga (Gibbs *et al*., 2017).

Southern migrating humpbacks pass along the west coast of the North and South Islands where they aggregate near the southwest corner of the South Island before moving further south. A small number of southern migrating whales pass the east coast of the North Island to East Cape where they depart offshore (Gibbs & Childerhouse, 2000). Recent satellite tagging of southern-migrating whales has revealed those that travel to the east of New Zealand typically congregate at the Kermadec Islands before proceeding south to two recently discovered Southern Ocean feeding areas (Riekkola *et al*., 2019). Southern migrations occur from mid-September to early December (Dawbin, 1986).

On their migrations, humpback whales can spend considerable time in coastal regions over the continental shelf (Jefferson *et al.*, 2008). Annual winter surveys of humpback whales occurred in Cook Strait over the 12 years from 2004 – 2015. During this period, 659 whales were observed (Gibbs *et al.*, 2017), with the number of individuals recorded yearly ranging from 15 (in 2006) to 137 (in 2015) (Gibbs *et al.*, 2017). From this data the calculated rate of population increase was 13% (5-22%, 95% Confidence Interval), suggesting the beginning of population recovery.

Both male and female humpbacks produce communication calls, but only males emit the long, loud, and complex 'songs' associated with breeding activities. Dunlop *et al*. (2007) recorded social vocalisations of migrating east Australian humpbacks and recorded frequencies ranging from <30 Hz to 2.5 kHz over 34 different vocalisation types. The source level of singing humpback whales ranges from 123 – 183 dB re 1 µPa @ 1 m (Dunlop *et al.,* 2013). Surface-generated social sounds (e.g. breaches, pectoral slaps, and tail slaps) are also generated by humpback whales and are thought to have a communicative function (Dunlop *et al.,* 2010). These surface-generated sounds have been reported to be in the range of 133 – 171 dB re 1 µPa @1 m (Dunlop *et al.,* 2013).

Humpback whales are occasionally seen in coastal Taranaki waters, particularly between the months of May and August on their northern migration. Nineteen sightings of humpback whales have been reported within the AOI and four stranding events have occurred along the coastline. While this species is known to occur within the AOI, the Turangi 3D Seismic Survey will coincide with summer/autumn months when this species is still expected to be feeding in high latitude Antarctic waters. Based on this, it is considered that humpback whales are **unlikely** to be in the AOI during the proposed seismic operations but will have a **possible** presence in winter.

Pygmy right whale (*Caperea marginata*)

Pygmy right whales are the smallest, most cryptic and least known of the living baleen whales (Fordyce & Marx, 2012). They are known to have a worldwide distribution and a diet consisting largely of calanoid copepods and euphausiids (Kemper, 2002). Globally, sightings are known from both oceanic and coastal habitats and a presence close to shore cannot be discounted (Kemper, 2009). New Zealand sightings typically occur near Stewart Island and Cook Strait (Kemper, 2002). Kemper *et al* (2013) suggests an association between pygmy right whales and areas of high marine productivity.

It has been assumed that pygmy right whale communication is similar to that of other baleen whales, in that this species communicates using loud low-pitched sounds (WhaleFacts, 2021). Recordings have documented calls of paired short thump-like pulses or tone bursts with a down-sweep in frequency and decaying amplitude. The energy of these calls was between 60 and 120 Hz, and recorded source levels were in the lower end of the range of baleen whale calls (Dawbin & Cato, 1992).

There have been no sightings of pygmy right whales in the AOI, and only two strandings have been reported inshore. This species is a **possible** visitor to the AOI; however most New Zealand sightings have occurred further south.

5.2.6.3 Toothed Whales (suborder Odonotoceti)

Sperm whale (*Physeter macrocephalus*)

Sperm whales have wide geographical and latitudinal distribution. While they do not carry out large scale migrations like those of the baleen whales, smaller movements occur, with animals in the Southern Hemisphere moving southward from the equator during winter months (April – September), returning north in summer (October – March) (Berzin, 1971).

Torres (2012) reported that sperm whale sightings in the Taranaki region typically occur in deep offshore waters and are limited to summer months. The offshore distribution of sperm whales is not surprising considering their main prey species is squid (Evans & Hindell, 2004; Gomez-Villota, 2007).

No sperm whale sightings have been reported from within the AOI, and although six stranding incidents have been reported from the coastline of the AOI, the offshore distribution of this species in Taranaki waters (as described by Torres (2012) suggests that they would be **unlikely** to be present in the Primary Operational Area and Testing Area during the Turangi 3D Seismic Survey; however, it is **possible** that they occasionally visit the AOI.

Pygmy sperm whales (*Kogia breviceps*)

Pygmy sperm whales are seldom observed at sea on account of their low profile in the water and lack of a visible blow; for this reason, little information is available on this species. They appear to show a preference for areas of offshore upwelling ranging from 400 – 1000 m in depth (SMM, 2020). Pygmy sperm whales are deep divers but do not restrict their feeding only to deeper areas (Dawson, 1985). Their prey items include cephalopods, fish and occasionally crustaceans (Shirihai & Jarrett, 2006).

Although sounds associated with echolocation, such as clicks, buzzes, and grating sounds, have been recorded, this species is not thought to be highly vocal (Ross, 2006). Data collected from live stranded animals has indicated that pygmy sperm whales emit click trains between 60 and 200 kHz (Marten, 2000).

No live sightings of this species have been recorded in the AOI, and only one stranding event has been reported for this coastline. Based on this information and their preference for deeper offshore water, pygmy sperm whales are **unlikely** to occur in the AOI

Beaked whales (Family Ziphiidae)

Although thirteen species of beaked whales have been reported in New Zealand (Baker *et al.*, 2016), their elusive behaviour at sea means that very little is known about their distributions (Baker, 1999). Most of the knowledge about beaked whales comes from stranded individuals. While **Table 8** outlines those species that have stranded inshore of the marine mammal AOI and provides a brief account of the ecology of each species, only one live sighting of a beaked whale has been recorded from the AOI (a Shepherd's beaked whale in Mokau Trench in 2014). In addition to those strandings listed in **Table 8**, a further three unidentified beaked whales have stranded along the coast of the AOI. It is noteworthy that beaked whales are generally considered to prefer deep water as they are deep divers and feed predominantly on deep-water squid and fish species. While it is **possible** that beaked whales may occasionally visit the AOI, their presence in the shallow coastal waters of the Primary Operational Area and Testing Area is **unlikely.**

Table 8 Beaked whale ecology of relevance to the Primary Operational Area and Testing Area

Species	No. of Stranding Events inshore of AOI	Ecology
Gingko-toothed whale *(Mesoplodon ginkgodens)*	1	Most stranding and capture records for this species are from the tropical and warm temperate waters of the Indo-Pacific (esp. Japan). Only a few records from New Zealand. Biology is unknown (Pitman & Brownwell, 2020a).
Strap-toothed whale *(Mesoplodon layardii)*	2	Occur between 35-60°S in cold temperate waters. Stranding seasonality suggest this species may migrate. Prefer deep waters beyond the shelf edge. Probably not as rare as other *Mesoplodon* sp. (Pitman & Brownwell, 2020b). Feeds on squid (Sekiguchi *et al.*, 1996). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).
Shepherd's beaked whale *(Tasmacetus shepherdi)*	2	A circumpolar distribution in cold temperate waters is presumed. All stranding events have occurred south of 30°, the majority from New Zealand. Thought to be relatively rare. Occur in deep water usually well offshore. Diet contains fish, squid and crabs (Braulik, 2018).
Cuvier's beaked whale *(Ziphius cavirostris)*	2	Thought to have the largest range of any beaked whale found in deep waters (> 200 m) of all oceans in both hemispheres. Thought to prefer steep bathymetry near the continental slope in water depths greater than 1,000 m. Feed mostly on squid and dive up to 40 minutes. Global abundance is likely to be well over 100,000 (Baird, *et al.*, 2020). Genetic studies suggest little movement of individuals between ocean basins (Dalebout *et al.*, 2005). Acoustic recordings of this species have been made in Cook Strait (Goetz, 2017).
Gray's beaked whale	3	This species has a circumpolar distribution south of 30° and occurs in deep waters beyond the shelf edge (Pitman & Brownwell, 2020c). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).

Long-finned pilot whale (*Globicephala melas)*

Pilot whale sightings occur in New Zealand waters during all seasons (Berkenbusch *et al.*, 2013), with sightings of pilot whales in Taranaki waters reasonably common, particularly in summer (Torres, 2012).

Pilot whales feed predominantly on cephalopods, with long-finned pilot whales also feeding on a number of fish species, particularly mackerel, cod, and dogfish (Olson, 2009). Both species forage at depth; deep dives are known to reach several hundred meters (Berkenbusch *et al.*, 2013).

Pilot whales are highly social, often travelling in large groups of over 100 individuals (DOC, 2019b). These whales commonly strand on New Zealand coasts, with the stranding rate peaking in spring and summer (O'Callaghan *et al.*, 2001). Farewell Spit is a recognised hotspot for pilot whale mass-stranding incidents; data from 1937 to 2017 reveal that at least 30 mass-stranding events had occurred, the largest of which involved approximately 416 individual whales. November, December and January are the most common months in which mass stranding events occur (DOC, 2010).

Pilot whales are known to be highly vocal when socialising at the surface (Jensen *et al.,* 2011), with vocalisations ranging from simple whistles while resting at the surface to complex whistles and pulses sounds during active behaviours (Weilgart & Whitehead, 1990). Calls of deep-diving pilot whales have been recorded with median peak frequencies of 3.9 kHz (Jensen *et al.,* 2011).

While sightings of pilot whales are common in offshore Taranaki waters, there Is only a single sighting record (of a group of three pilot whales) for this species in the AOI and only two recorded stranding events. Based on this data, occasional presence in the AOI is **possible** but this species is generally encountered further offshore.

Hector's dolphin (*Cephalorhynchus hectori hectori* and *C. hectori maui*)

There are two subspecies of Hector's dolphin: South Island Hector's dolphin (*Cephalorhynchus hectori hectori*) and the Māui's dolphin (*C. hectori maui*). In general, Māui's dolphins are present on the west coast of the North Island, and South Island Hector's dolphins are present around the South Island. Over the last 40 years, numbers of both subspecies have significantly declined, largely on account of high levels of by-catch in coastal fisheries (Roberts *et al*., 2019); with other threats such as disease (i.e. toxoplasmosis) a recent focus of scientific studies. Both subspecies are conservation dependent, with South Island Hector's dolphin being listed as 'nationally vulnerable' by the New Zealand Threat Classification System and Māui's dolphins listed as 'critically endangered. Māui's dolphins are of greatest relevance to the Turangi 3D Seismic Survey and the West Coast North Island Marine Mammal Sanctuary, which overlaps with the Primary Operational Area and Testing Area, was established to protect Māui's dolphins from threats throughout their distribution.

Māui's and Hector's dolphins cannot be readily differentiated at sea which complicates sightings records; however, there is no evidence to suggest that the ecology of the two subspecies is substantially different (Torres, 2012). Both subspecies have coastal distributions thought to be largely constrained within the 100 m isobath (Slooten *et al.*, 2006; Du Fresne, 2010); although, Māui's dolphins have been observed out to 12 M offshore during research surveys (DOC, 2017) and South Island Hector's dolphins have been observed out to 20 NM offshore during surveys (MacKenzie & Clement, 2014). In addition, non-systematic sightings of both subspecies out to 24 NM have been reported (Du Fresne, 2010), but these offshore sightings are typically associated with regions where the continental shelf extends well offshore (Constantine, 2019). Smaller-scale seasonal patterns of movement are apparent for both subspecies (particularly for East Coast South Island dolphins) with summer densities generally being highest close to shore, while in winter their distributions are broader both offshore and alongshore (Constantine, 2019). Despite these movements, both subspecies are characterised by having small home ranges averaging ~50 km alongshore (Oremus *et al.*, 2012). As with all populations, individual variation in range occurs with some individuals undertaking movements up to 100 km (Bräger *et al.*, 2002), and in addition, South Island Hector's dolphins have been genetically identified off the west coast of the North Island (Hamner *et al.*, 2012), confirming some degree of long range movement (~400 km) between populations.

Both Māui's and Hector's dolphins have a strong preference for turbid waters (Derville *et al.*, 2016) that are often associated with river or estuary outflows. These areas of high productivity would typically support abundant prey species on which the dolphins feed (Constantine, 2019). Based on stomach content analysis, this species has a diet consisting of a variety of fish species, with red cod, ahuru, arrow squid, sprat, sole, and stargazer contributing the majority (77%) of the total diet (Miller *et al.*, 2013). Dolphins are thought to undertake movements within their home-ranges in response to seasonal and diel movements of preferred prey (Constantine, 2019).

Māui's dolphins are only found along the West Coast of the North Island, with a population stronghold between Manakau Harbour and Port Waikato (Slooten *et al.*, 2005). While their total distribution is wider, extending from Maunganui Bluff (Currey *et al.*, 2012) to Taranaki (DOC, 2021b), information about habitat use at the extremes of their distributional range is scarce. The most recent Māui's dolphin population estimate for individuals aged one year and over is 54 individuals (95% CI = 48–66) (Constantine *et al.*, 2021). Māui's dolphins occur in very low densities in Taranaki waters (Currey *et al.*, 2012), although acoustic monitoring has recently been used to attempt to quantify their presence off Taranaki (Nelson & Radford, 2019). This study used C-POD click detectors moored approximately 2 km offshore during several deployments between November 2016 and April 2019 at the locations listed in **Table 9**. No deployments occurred in the direct vicinity of the Primary Operational Area and Testing Area for the Turangi 3D Seismic Survey, but these areas lie between the Motunui (approximately 6.6 km to the west) and Paraninihi (approximately 9.5 km to the north-east) deployment locations.

Table 9 C-POD deployments in Taranaki

Deployment	Duration	Locations
1	18 November 2016 to 4 May 2017	Tongaporutu, New Plymouth Airport, Whanganui River
2	15 January 2018 to 3 July 2018	Tongaporutu, Motunui
3	9 July 2018 to 14 December 2018	Tongaporutu, Paraninihi
4	7 December 2018 to 16 April 2019	Awakino, Tongaporutu, Paraninihi, Tapuae

Note: Reproduced from Nelson & Radford, 2019

During these deployments, Māui's dolphins were acoustically detected only at the Tonagporutu and Tapuae sites; where click trains were detected in January 2017, April 2018, June 2018, and October 2018 for Tongaporutu and December 2018 for Tapuae (Nelson & Radford, 2019). Of the Tongaporutu detections the highest number occurred in spring. DOC has interpreted this to confirm that Māui's dolphins are regularly present in the coastal waters of Tongaporutu and visit as far south as Tapuae (DOC, 2021b). This information reinforces the notion introduced by Currey *et al*. (2012) that Māui's dolphin densities decrease towards the southern extremities of their alongshore range (i.e. through Taranaki and Whanganui) and that both the density and rate of occurrence for Māui's dolphins in the Primary Operational Area and Testing Area for the Turangi 3D Seismic survey will be very low.

Sixty five sightings of Hector's/Māui's dolphins have been reported in the Marine Mammal AOI. This high level of reporting (relative to other species) is a result of a concerted effort by DOC to encourage members of the public to report sightings of this species (especially in those parts of their range where densities are very low e.g. coastal Taranaki) via several hotlines, mobile phone apps or online reporting forms. These public awareness and reporting campaigns have been very successful in collecting sightings data for Māui's dolphins (that is subsequently validated by a marine mammal scientist) over recent years (particularly in the lead up to the Threat Management Plan review for this species). In addition, eleven strandings of Māui's dolphins have been reported along the coastline of the Marine Mammal AOI; although these strandings all occurred in the 1970's and 1980's.

Based on the information above, and despite their very low densities off the Taranaki coast, it is **possible** that Hector's or Māui's dolphins could be present in the AOI during the Turangi 3D Seismic Survey. Given the 'nationally critical' threat status of Māui's dolphins this possibility has been seriously considered during the planning phase of the Turangi 3D Seismic Survey; hence, NZSL have committed to:

- Ensuring that two MMOs and at least one PAM Operator are on duty at all times when the acoustic source is in the water;
- Restricting seismic operations to during daylight hours; and
- Treating the first source activation of each survey day as a 'new location' with additional pre-start observation requirements in poor sighting conditions.

Common dolphin (*Delphinus delphis*)

Common dolphins are abundant and widespread throughout tropical and temperate oceans of the Atlantic and Pacific Ocean and occur in waters encompassing all New Zealand regions (Berkenbusch *et al.*, 2013). They occur around most of the New Zealand coastline, with their occurrence restricted by seasonal fluctuations in sea surface temperature (Webb, 1973); common dolphins are generally observed in coastal waters during spring and summer, moving further offshore in autumn (Stockin *et al.*, 2008).

Common dolphins forage on small schooling fish and squid (Rossman, 2010). Stomach content analysis from common dolphins in New Zealand indicate that jack mackerel, anchovy, and arrow squid are their primary prey species (Meynier *et al.*, 2008).

Common dolphins are a highly social species which often forms large groups consisting of thousands of individuals. Individuals within large groups will often forage co-operatively; observed tactics include co-operative rounding-up of schooling fish into bait balls (Stockin, 2008). Throughout New Zealand common dolphins have been observed in mixed species aggregations with Bryde's whales (Stockin, 2008).

Common dolphins are highly vocal and use a variety of vocalisations including whistles, echolocation click-trains, burst pulse calls (Richardson *et al*., 1995; Soldevilla *et al*., 2008), and other non-whistle pulsed sounds referred to as barks, yelps, or squeals (Ridgway, 1983). Petrella *et al*. (2012) determined the whistle characteristics of common dolphins in the Hauraki Gulf, New Zealand, indicating that the average frequency and length of whistles are 10 – 14 kHz and 0.27 seconds, respectively.

Common dolphins are the most frequently encountered cetacean species Taranaki (Torres, 2012). Most sightings occur over summer months, but this seasonality could simply reflect an observational bias over the summer months (Torres, 2012). Eighty six sightings of common dolphins have been reported within the AOI, with the single largest sighting estimated at 130 individuals. Stranding events are also relatively common inshore, with 15 stranding events reported along the AOI coastline. Common dolphins are therefore **likely** to be present in the AOI during the Turangi 3D Seismic Survey.

Dusky dolphin (*Lagenorhynchus obscurus*)

Dusky dolphins are a coastal species that is distributed throughout the Southern Hemisphere (Berkenbusch *et al.*, 2013). They are present year-round in New Zealand waters where they occur above the continental slope and shelf in water depths less than 2,000 m, usually in the cooler waters of the South Island and lower North Island; population concentrations exist around the Kaikoura Peninsula and Admiralty Bay in the Marlborough Sounds (Wűrsig *et al.*, 2007). Dusky dolphins tend to spend more time in offshore waters during winter months. While little is known about their movements, photo-identification data confirms that individuals can travel up to 1,000 km between locations (Wűrsig *et al.*, 2007).

Dusky dolphins are sociable and are commonly found in grouping of a dozen or more individuals, with pods of several hundreds to thousands occurring in open-ocean environments (Wűrsig *et al*., 1997). These aggregations are often temporary, with dolphins frequently changing affiliations (Wűrsig *et al.*, 2007).

Only one dusky dolphin sighting has been made within the AOI and only two stranding events have been reported. Based on this data it is **possible** that this species could be present in the AOI during the proposed seismic operations, but the preference of this species is for cooler South Island waters.

Killer whale (*Orcinus orca*)

Killer whales are found in all marine regions, from the equator to polar waters (Reeves *et al*., 2017). There have been four morphological forms (referred to as ‘ecotypes’) described in the southern hemisphere (Types A – D (Pitman *et al*., 2011)), with New Zealand being the only place where three out of the four ecotypes have been reported (Pitman *et al*., 2011; Foote *et al*., 2013). New Zealand’s coastal ecotype killer whale population is small (65 – 167 individuals (Visser, 2006)) and is made up of at least three possible sub-populations based on geographic distribution; a North Island only subpopulation, South Island only subpopulation, and a North and South Island sub-population (Visser, 2000). The abundance of other ecotypes utilising New Zealand waters is unknown.

Killer whales are wide-ranging, with some New Zealand whales estimated to travel an average of 100 – 150 km per day (Visser, 2007). High re-sighting rates of some identifiable individuals suggest killer whales live permanently or at least semi-permanently around New Zealand’s coast (Visser, 2007); however, the mobility of this specs and their opportunistic foraging behaviour (Visser, 2000) indicates that this species can readily move between areas to maximise foraging opportunities and avoid disturbances.

Killer whales form social groups that range in size from small stable units and 'resident societies' to larger temporary aggregations of over 20 individuals (Ford, 2009). The smaller groups are usually based on maternal descent and consist of a matriarch and up to four generations of her offspring (Berkenbush *et al.*, 2013).

Diet and foraging strategy differ based on family groups, with prey type also influencing foraging strategy. In general, the diet of killer whales consists of four types; sharks, rays, fin-fish, and marine mammals. Rays are the most common prey type and food sharing is common amongst killer whales (Visser, 2000).

Echolocation characteristics vary between groups of whales and are thought to reflect the target prey species (Barrett-Lennard *et al*., 1996). Whistles have an average dominant frequency of 8.3 kHz (Thomsen *et al*., 2001) and variations of these whistles (often referred to as dialects) have been documented between pods (Deecke *et al*., 2000).

Forty one killer whale sightings have been recorded within the AOI, including one sighting of 10 individuals and several sightings noting the presence of calves and/or that animals were foraging for rays in shallow coastal waters. Strandings for this species are rare, with no strandings reported for the AOI. Killer whales are **likely** to utilise waters of the AOI and could be present during the Turangi 3D Seismic Survey.

5.2.7 Pinnipeds

There are nine species of pinniped known from New Zealand waters; however, only the New Zealand fur seal is discussed further as it is the only pinniped species likely to occur in the AOI. All other species are routinely only found along the southern coast of the South Island, or in the sub-Antarctic.

New Zealand Fur Seal

New Zealand fur seals are native to both New Zealand and Australia. Within New Zealand they are widespread around rocky coastlines on the mainland and offshore islands (Wilson, 1981).

The closest fur seal colony of relevance to the Primary Operational Area and Testing Area is at Ngā Motu/the Sugar Loaf Islands, 30 km west-southwest of the Primary Operational Area and 2 km west of the Testing Area; smaller haul-out sites are present throughout the Taranaki coast, although these do not meet the definition of a colony/rookery (Miller & Williams, 2003). Despite its proximity to New Plymouth urban areas and a busy commercial port, Ngā Motu and associated rock groups provide permanent haul-out and breeding grounds for fur seals (Miller & Williams, 2003). Population numbers within the Ngā Motu area appear to be stable, with a lack of suitable habitat for hauling out and breeding likely limiting population growth (Miller & Williams, 2003).

New Zealand fur seals are opportunistic feeders that forage on a range of species, with the relative importance of each prey item varying seasonally and geographically (Baird, 1994). Arrow squid are important prey items in summer and autumn, lanternfish are taken year-round, barracouta and jack mackerel are major contributors to the summer diet, while pink cod, ahuru and octopus are important winter prey species (Harcourt *et al.*, 2002). In general, their diet shifts from a squid-dominated diet in summer and autumn, to mixed fish-dominated in winter (Harcourt *et al.*, 2002). Foraging habitats vary with season and sex although inshore and deeper offshore foraging habitat is used throughout the year (Harcourt *et al.*, 2002). Females tend to forage over continental shelf waters, with males using deeper continental shelf breaks and pelagic waters (Page *et al.*, 2005). Foraging trips often last for several days (Page *et al.*, 2005) and GPS tagged animals have shown females to forage up to 78 km from breeding colonies (Harcourt *et al.*, 1995), foraging further offshore in winter (Harcourt *et al.*, 2002).

The breeding season for New Zealand fur seals occurs from mid-November to mid-January, with peak pupping in mid-December (Crawley & Wilson, 1976; Miller & Williams, 2003). Pups are suckled for approximately 300 days, during which adult females alternate between foraging at sea and returning to shore to feed their young (Boren, 2005).

Sightings of fur seals, both ashore and at sea, along the AOI are common; hence, this species is **likely** to be present in the AOI during the proposed seismic operations. It is however noteworthy that foraging for this species typically occurs further offshore and the number of sightings reported in the DOC Sightings Database is biased low based on the infrequent reporting of this common species.

5.2.8 Marine Reptiles

Nine species of marine reptile have been recorded in New Zealand waters: the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), leatherback/leathery turtle (*Dermochelys coriacea*), yellow-bellied sea snake (*Pelamis platurus*), Saint Giron's sea krait (*Laticauda colubrina*), common/blue-lipped sea krait (*L. laticaudata*) and the banded/yellow-lipped sea krait (*L. colubrina*) (DOC, 2021c; DOC, 2021d).

Due to their preference for warmer temperate and more tropical waters, most of New Zealand's marine reptiles are found off the northeast coast of the North Island (DOC, 2021e). Marine reptiles occasionally visit the south-western coast of the North Island, although this occurs mainly during summer months when the warmer currents push down the western side of New Zealand. Logger head turtles, leatherback turtles, olive ridley turtles, and yellow-bellied sea snakes have been observed in Taranaki waters (DOC, 2021e); however, they are ***rare visitors*** and are not routinely present.

5.2.9 Seabirds

'Seabirds' covers those species that spend some part of their life cycle feeding over open marine water; this is compared to 'waders' that feed in the intertidal (Taylor, 2000). The Taranaki region is visited by several bird species that either pass through the region or use the area as a foraging destination. Approximately 60% of New Zealand's seabirds regularly forage more than 50 km from shore, while the remaining feed over inshore waters and are only occasionally sighted away from land (Taylor, 2000).

DOC has assessed each bird found within New Zealand and assigned a threat classification. Many of the birds present in New Zealand have a threatened classification (i.e. classified as nationally critical, nationally endangered, or nationally vulnerable), with several of these amongst the rarest and most critically endangered of New Zealand's breeding birds (Taylor, 2000).

Various references (e.g. Scofield and Stephenson (2013); Robertson *et al.* (2017); New Zealand Birds Online (2021)) have been used to identify the seabirds that may be observed in and around the Primary Operational Area and Testing Area – due to their wide ranges, coastal bird species (i.e. intertidal waders and those that forage within the CMA) present in the Taranaki region have been included. A summary of the seabirds, including their threat classifications (both the IUCN and New Zealand Threat Status), is presented in **Table 10**.

Within the PCP, TRC has identified a number of birds as being regionally significant on account of their coastal indigenous biodiversity values (TRC, 2018). Caspian tern, banded dotterel, reef heron, royal spoonbill, variable oystercatcher, white heron, and grey-faced petrels are also considered to be 'regionally distinctive' within the Taranaki Draft Coastal Plan.

Table 10 Seabirds potentially present in the Primary Operational Area and Testing Area

Common Name	Scientific Name	IUCN Threat Status (www.iucnredlist.org)	NZ Threat Status (Robertson *et al.*, 2017)
Marine foragers – CMA waters			
Flesh-footed shearwater*	*Puffinus carneipes*	Near threatened	Nationally vulnerable
Little penguin*	*Eudyptula minor*	Least concern	Declining
Sooty shearwater*	*Puffinus griseus*	Near threatened	Declining
Cook's petrel	*Pterodroma cookii*	Vulnerable	Relict
Fairy prion*	*Pachyptila turtur*	Least concern	Relict
Fluttering shearwater*	*Puffinus gavia*	Least concern	Relict
Northern diving petrel*	*Pelecanoides urinatrix urinatrix*	Least concern	Relict
White-faced storm petrel*	*Pelagodroma marina maoriana*	Least concern	Relict
Antarctic prion*	*Pachyptila desolata*	Least concern	Naturally uncommon
Buller's shearwater*	*Puffinus bulleri*	Vulnerable	Naturally uncommon
Little black shag*	*Phalacrocorax sculcirostris*	Least concern	Naturally uncommon
Westland petrel	*Procellaria westlandica*	Endangered	Naturally uncommon
Cape pigeon	*Daption capense capense*	Least concern	Migrant
Short-tailed shearwater	*Puffinus tenuirostris*	Least concern	Migrant
Australasian gannet	*Morus serrator*	Least concern	Not threatened
Grey-faced petrel*	*Pterodroma gouldi*	Least concern	Not threatened
Red-billed gull	*Larus scopulinus*	Least concern	Declining
Caspian tern*	*Hydroprogne caspia*	Least concern	Nationally vulnerable
Little pied shag	*Phalacrocorax melanoleucos brevirostris*	Least concern	Vagrant
Pied shag*	*Phalacrocorax varius varius*	Least concern	Recovering
Intertidal foragers			
Great egret/White heron*	*Ardea alba modesta*	Least concern	Nationally critical
Reef heron*	*Egretta sacra sacra*	Least concern	Nationally endangered
Banded dotterel*	*Charadrius bicinctus*	Least concern	Nationally vulnerable
Lesser/Red knot*	*Calidris canutus rogersi*	Near threatened	Nationally vulnerable
Bar-tailed godwit*	*Limosa lapponica*	Near threatened	Declining
South Island pied oystercatcher*	*Haematopus finschi*	Least concern	Declining
White-fronted tern*	*Sterna striata*	Near threatened	Declining
Variable oystercatcher*	*Haematopus unicolor*	Least concern	Recovering
Black-fronted dotterel	*Elseyornis melanops*	Least concern	Naturally uncommon
Royal spoonbill*	*Platalea regia*	Least concern	Naturally uncommon
Pacific golden plover	*Pluvialis fulva*	Least concern	Migrant

Common Name	Scientific Name	IUCN Threat Status (www.iucnredlist.org)	NZ Threat Status (Robertson *et al.*, 2017)
Ruddy turnstone	*Arenaria interpres*	Least concern	Migrant
Curlew sandpiper	*Calirdis ferruginea*	Near threatened	Vagrant
Black swan	*Cygnus atratus*	Least concern	Not threatened
Kelp gull	*Larus dominicanus dominicanus*	Least concern	Not threatened
Kingfisher	*Todiramphus sanctus vagans*	Least concern	Not threatened
Masked lapwing	*Vanellus miles novaehollandiae*	Least concern	Not threatened
Pied stilt*	*Himantopus himantopus leucocephalus*	Least concern	Not threatened
White-faced heron	*Egretta novaehollandiae*	Least concern	Not threatened

* Species that have been identified as regionally significant on account of their coastal indigenous biodiversity values

5.2.9.1 Kororā/Little Penguin Breeding and Foraging Areas

Little penguins, or more commonly known as little blue penguins, are the world's smallest species of penguin and are the most common species of penguin found around New Zealand's mainland, although with the exception of within the Taranaki region, there are few colonies along the North Island's west coast (Wilson & Mattern, 2018). They forage at sea during the day, returning at night to their burrows (NZBirdsOnline, 2020). Little blue penguins generally return to their natal colony for breeding and retain their pair bond and often the same burrow year after year (Wilson & Mattern, 2018).

Taranaki's Project Hotspot (a citizen-science project driven by the Nga Motu Marine Reserve Society) has reported little blue penguins in the vicinity of the Primary Operational Area and Testing Area, including a sighting of birds while in the burrow. Several nesting penguins have been reported in the vicinity of Port Taranaki and along the coastline between Port Taranaki and the Primary Operational Area (Project Hotspot, 2021).

During the breeding season little blue penguins usually forage within 30 km of the nest, foraging further out to sea following completion of chick-rearing (Mattern *et al*., 2001; Zhang *et al*., 2015); penguins GPS-tracked from Marlborough Sounds nesting sites have been tracked undertaking foraging trips up to 214 km from nests (Poupart *et al*., 2017). Little blue penguins forage on nearshore pelagic schooling fish, squid and crustaceans which they hunt during dives to depths up to 50 m (Chiaradia *et al*., 2007). Foraging areas are influenced by areas of enhanced productivity, including areas down-current of plumes from rivers with high nutrient concentrations (Dagg *et al*., 2004); for example, Poupart *et al.* (2017) found a positive relationship between the mean maximum foraging distance and distance to a large river in GPS-tracked little blue penguins, indicating that the penguins were actively seeking such areas.

5.3 Coastal Environment and Marine Conservation

5.3.1 Regional Coastal Environment

Taranaki's coastline encompasses a broad range of habitats including rocky shores and cliffs, sandy beaches, subtidal reefs, river mouths, and estuaries. The intertidal reef systems along the coast generally have a lower species diversity and abundance than similar system types elsewhere in New Zealand. Taranaki's high-energy coastline gives rise to abrasive and turbulent shoreline conditions, high water turbidity, suspended silt, and sand inundation (TRC, 2009).

Under the PCP, the TRC has divided the coast into five Coastal Management Areas – recognised for their values, characteristics or uses, that are vulnerable or sensitive, or that require different management styles (TRC 2016). The Coastal Management Areas are:

- Outstanding Value Areas – areas that have outstanding natural character and areas identified as outstanding natural features and landscapes. These areas contain values and attributes (such as landforms, cultural and historic associations, and visual qualities) that are exceptional. Outstanding Value Areas are further defined as either Areas of Outstanding Natural Value or Areas that are Outstanding Natural Features or Landscapes;
- Estuaries Unmodified – estuaries that have not been significantly modified, including the surrounding area and environment;
- Estuaries Modified – estuaries that are highly modified and are surrounded by urban and extensively modified environments. Although modified, these areas retain indigenous biodiversity values, amenity values, and contain significant habitats;
- Ports – covers Port Taranaki which contains regionally and nationally important infrastructure; and
- Open Coast – the area within the CMA not covered by other management areas.

The PCP also includes Sites with Significant Amenity Values based on the natural or physical qualities and characteristics that contribute to the pleasantness, aesthetic coherence, and cultural and recreational attributes. These sites are in addition to the Areas of Outstanding Natural Character and Areas that are Outstanding Natural Features or Landscapes and include beaches, reefs, and estuaries and river mouths. 103 Significant Surf Breaks and Nationally Significant Surfing Areas, and 29 Sites of Geological Significance have also been identified within the Proposed Coastal Plan for the wider Taranaki Region (TRC, 2018).

There are no Areas of Outstanding Natural Value or Areas that are Outstanding Natural Features or Landscapes that overlap with, or lie inshore of the Primary Operational Area or Testing Area; however, Mimi Estuary lies 600 m east of the Primary Operational Area and is designated as an Area of Outstanding Natural Character.

The Tapuae Marine Reserve and Ngā Motu/the Sugar Loaf Islands are also considered to be areas of Outstanding Natural Character and Outstanding Natural Features or Landscapes. These areas are approximately 1.6 km to the west of the Testing Area and are discussed in further detail in **Section 5.3.2.1** and **5.3.2.2** respectively. Two Estuaries Unmodified lie inshore of the Primary Operational Area; Urenui Estuary and Onaero Estuary.

The PCP describes the values of Mimi Estuary as relatively unmodified with exceptional biophysical values and high scenic associations. **Table 11** provides further details on the marine qualifying values found within Mimi Estuary, as described within the PCP.

Table 11 Marine qualifying characteristics of Mimi Estuary

Natural character attributes	Values and characteristics	Degree of natural character
Abiotic	Diverse and rare range of habitat types including riverine estuary, small tidal bays, estuary margins, and sandy foreshore. Unmodified natural processes including sand spit and dune processes and river mouth oscillations.	Very high
Biotic	Small tidal bays contain a variety of specialised native flora. Provides important habitats for a diverse range of resident and migratory birds including Northern New Zealand dotterel, Caspian tern, and red-billed gull. Margins of the south side of the estuary contains a well established variety of mainly native plants. The estuary contains diverse and regionally distinctive native fish.	Very high
Perceptual and experiential	Human activity is minimal associated with low impact recreation use. The experience maintains a sense of remoteness and high scenic associations.	High

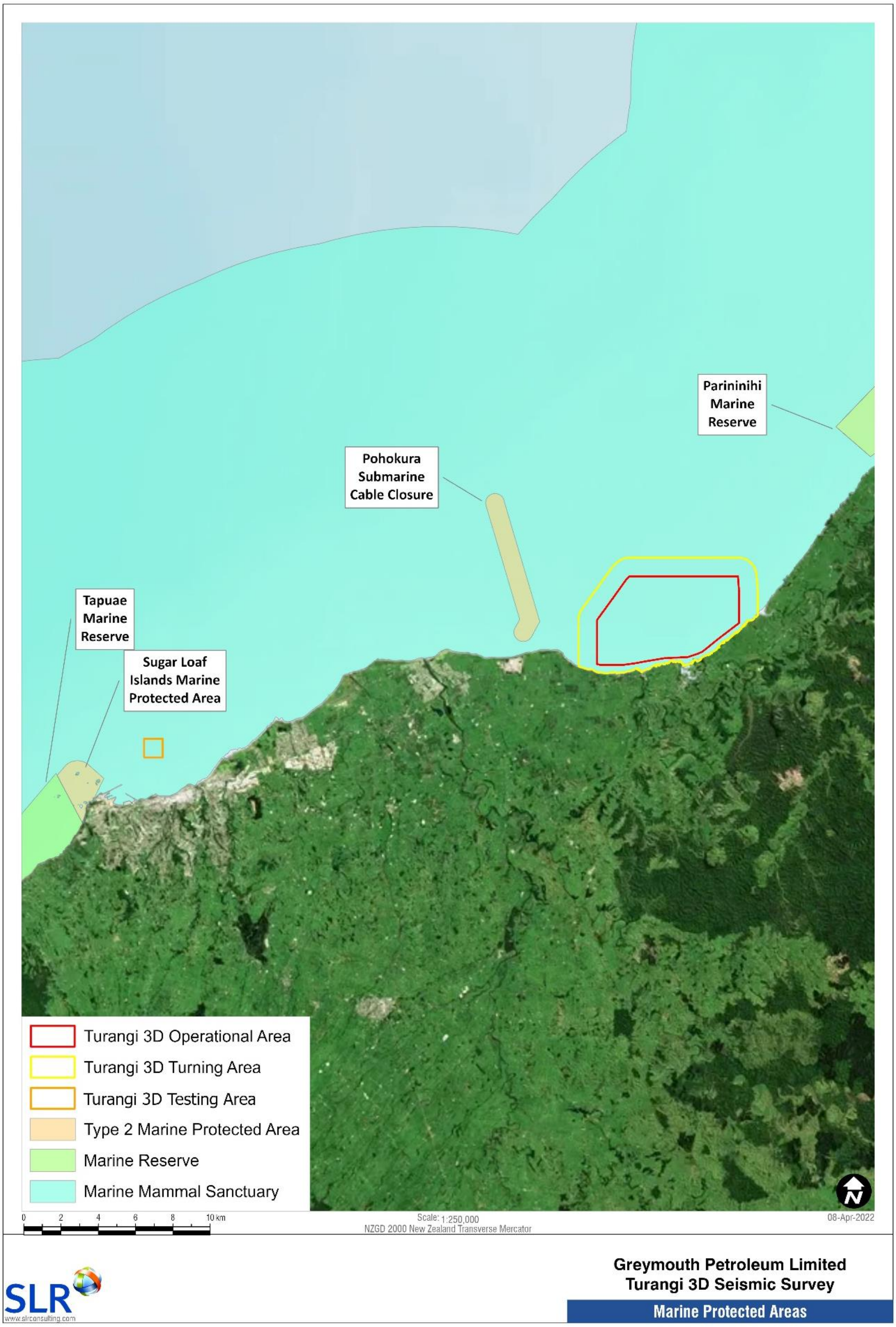
5.3.2 Marine Protected Areas

Protected Natural Areas are areas that have been put in place for the conservation of biodiversity. These areas receive varying degrees of protection and are managed under size 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 1978. New Zealand has three levels of marine protection:

- Type 1 Marine Protected Areas – provide the highest level of marine protection and covers the Marine Reserves (as established under the Marine Reserves Act 1971). Marine Reserves are the responsibility of DOC and are established with the main aim of creating an area free from alterations to marine habitats and life in order to provide a comparison for scientists to study. All extractive activities are prohibited within the boundaries of a marine reserve, although non-extractive activities (e.g. boating, kayaking, snorkelling and diving) may continue (DOC, 2021f);
- Type 2 Marine Protected Areas – include Marine Protected Areas, Marine Parks, Marine Management Areas, Mātaitai, Submarine Node and Pipeline Protection Zones, and fisheries closures (DOC, 2021g); and
- 'Other' marine protection tools – Include Benthic Protection Areas, Seamount Closures, Marine Parks, and Marine Mammal Sanctuaries. These are similar to Type 1 and Type 2 areas but do not protect sufficient biodiversity to meet the required protection standard (DOC, 2021h).

Marine Protection Areas of relevance to the Primary Operational Area and Testing Area are shown in **Figure 11**.

Figure 11 Marine Protected Areas of relevance to the Primary Operational Area and Testing Area



5.3.2.1 Marine Reserves

The closest Marine Reserve to the Primary Operational Area is the Parininihi Marine Reserve, which lies approximately 8.5 km to the north east. This Marine Reserve covers a 'typical slice of North Taranaki coastline' and includes the Pariokariwa Reef which is valued for its unique sponge gardens and diversity of other encrusting species. A variety of fish species and large rock lobster populations are also present within the boundaries of the Marine Reserve (DOC, 2021i).

The Tapuae Marine Reserve lies approximately 4.2 km to the west of the Testing Area (and 30 km west of the Primary Operational Area) where it adjoins the Ngā Motu/Sugar Load Islands Marine Protected Areas. The northern end of this reserve covers the remains of an ancient volcano, with the resulting pinnacles, canyons and caves providing habitat for approximately 400 fish species, as well as reef species of sponges, shellfish and bryozoans. The southern part of the reserve is typical of the Taranaki coast (DOC, 2021j).

5.3.2.2 Type 2 Marine Protected Areas

There are no Marine Protected Areas or Mātaitai Reserves in the vicinity of the Primary Operational Area or Testing Area.

The Ngā Motu/Sugar Loaf Islands Marine Protected Area lies 2 km to the west of the Testing Area and comprises the seabed, foreshore, and water around Ngā Motu/the Sugar Loaf Islands. Habitats within this area include canyons, caves, rock faces with crevices and overhangs, large pinnacles, boulder fields, and extensive sand flats. At least 89 species of fish, 33 species of encrusting sponge, 28 species of bryozoans, and 9 nudibranch species occur within the area. The islands are important for breeding seabirds, with approximately 10,000 nesting here. A New Zealand fur seal colony is also located on Ngā Motu/the Sugar Loaf Islands (DOC, 2021k).

The Pohokura Submarine Cable Closure, which lies approximately 3 km to the west of the Primary Operational Area, was established to protect the Pohokura platform and associated pipelines. Anchoring and most types of fishing are banned from within the closure to prevent pipeline damage.

5.3.2.3 Other Marine Protected Areas

The West Coast North Island Marine Mammal Sanctuary is the only 'Other' Marine Protected Area of relevance to the Primary Operational Area and Testing Area, the boundaries of which overlap with these areas.

The West Coast North Island Marine Mammal Sanctuary was established in 2008 as part of the Hector's and Māui's dolphin Threat Management Plan. The aim of the sanctuary is to protect the threatened Māui's dolphin, primarily from fishing impacts.

In 2013, the sanctuary was varied to prohibit commercial and recreational set-netting fishing between 2 and 7 NM offshore from Pariokariwa Point to the Waiwhakaiho River in order to provide greater protection to Māui's dolphins. This variation added 350 km^2 to the sanctuary (DOC, 2021l).

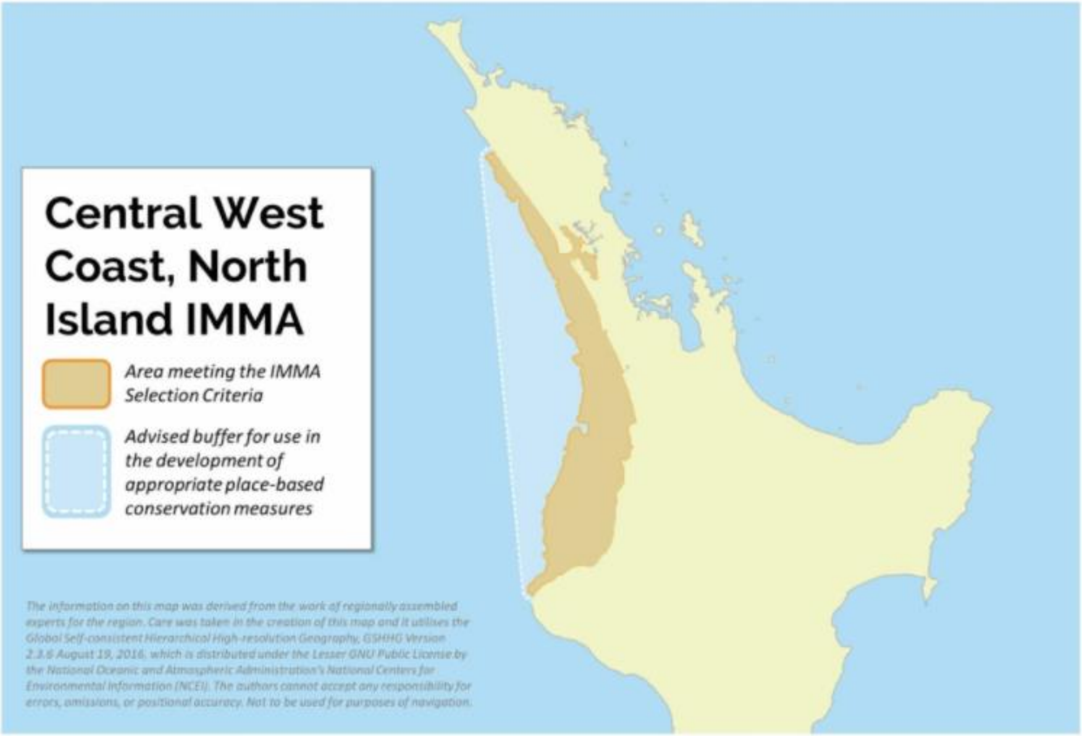
Following the 2013 review, the Hector's and Māui's Dolphin Threat Management Plan was again reviewed in 2018/2019, with the Minister of Conservation and Minster of Fisheries announcing their decisions on new measures arising from the review in June 2020. An extension to several Marine Mammal Sanctuaries has been adopted as part of this review, including to the West Coast North Island Marine Mammal Sanctuary. The sanctuary boundary now extends south to Wellington adding an extra 8,531 km^2 of protection. The extension to the West Coast Marine Mammal Sanctuary was announced on 1 October 2020 and came into force on 5 November 2020 under the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020 (DOC, 2021m). A portion of the West Coast North Island Marine Mammal Sanctuary, as is relevant to the Turangi 3D Seismic Survey, is shown in **Figure 11**.

5.3.3 Important Marine Mammal Areas

A recent development in marine mammal conservation in New Zealand has been the identification of 'Important Marine Mammal Areas' based on the recommendations of the IUCN's 'Marine Protection Area Task Force'. This Task Force has identified the majority of the North Island's west coast as an Important Marine Mammal Area, including around the Primary Operational Area and Testing Area (**Figure 12**). The two key reasons behind the designation of the 'Central West Coast, North Island Important Marine Mammal Area' are listed as Criterion A (species or population vulnerability) and Sub-criterion B (small and resident populations) due to the presence of Māui dolphins. Transient bottlenose dolphins and killer whales also utilise the area, and common dolphins forage in the nearshore coastal waters (MMPATF, 2021).

It is important to note that Important Marine Mammal Areas are areas identified as important for a marine mammal population but do not offer protection of a population such as would be provided by a Marine Mammal Sanctuary or Marine Reserve. Their purpose is solely to inform decision-makers when assessing the effects of activities on marine environments (MMPATF, 2021).

Figure 12 Central West Coast, North Island Important Marine Mammal Area



The information on this map was derived from the work of regionally assembled experts for the region. Care was taken in the creation of this map and it utilises the Global Self-consistent Hierarchical High-resolution Geography, GSHHG Version 2.3.6 August 19, 2016, which is distributed under the Lesser GNU Public License by the National Oceanic and Atmospheric Administration's National Centers for Environmental Information (NCEI). The authors cannot accept any responsibility for errors, omissions, or positional accuracy. Not to be used for purposes of navigation.

Source: MMPATF, 2021

5.3.4 Sensitive Habitats

Schedule 4B of the PCP lists several sensitive marine benthic habitats that may occur in the CMA. These are habitats where there is a low tolerance to damage from an external factor and where the time taken for subsequent recovery from sustained damage is significant (TRC, 2018). Sensitive habitats listed within the PCP and which have been recorded as present within or in the vicinity of the Primary Operational Area and Testing Area (based on the findings of Johnston, 2016) are:

- Rhodolith beds;
- Sponge gardens;
- Bryozoan thickets; and
- Beds of large bivalve molluscs.

5.4 Cultural Environment

Aotearoa’s marine environment is highly valued by all Māori and plays an important role in historic and present-day culture. The values placed on the marine environment stem in particular from the importance of estuaries and coastal waters as a valuable source of kaimoana (seafood). The marine environment is also regarded as a sacred and spiritual pathway which provides a means of transportation and communication. Many of Aotearoa’s ika (marine fauna) play important roles in legends. In particular, Māori have a deep spiritual connection with whales and dolphins, which are thought to provide safety at sea and reportedly guided the founding waka (canoes) on their great journey to Aotearoa from ancestral homelands in the Pacific.

Māori believe in the importance of protecting Papatuanuku (the earth) including the footprints and stories left by ancestors. In accordance with this, the role of kaitiakitanga (guardianship) is passed down between generations. Kaitiakitanga is central to the preservation of wāhi tapu (sacred places or sites) and taonga (treasures).

New Zealand’s coastline contains many sites of cultural significance. Wāhi tapu are sacred sites and include areas such as urupā (burial sites), ceremonial or funeral sites, pā (fortified villages), and battlegrounds where blood was spent, as well as places or objects of historic significance to whanau, hapū or iwi. In addition to wāhi tapu sites, some coastal areas were (and still are) important mahinga kai (food gathering sites) of significance to Māori ancestral history or represent the river mouths of taonga rivers.

There are eight recognised iwi within the Taranaki Region; Ngāti Tama, Ngāti Mutunga, Te Atiawa, Ngāti Maru, Taranaki, Ngāruahine, Ngāti Ruanui, and Ngaa Rauru. All eight iwi have traditions that demonstrate and ancestral, cultural, historical and spiritual connection to the coastal environment. The Primary Operational Area lies within the rohe of Ngāti Mutunga (TRC, 2018) and the testing area is relevant to the rohe of Te Atiawa (TRC, 2018) (**Figure 13**). As the majority of effects will occur in the Primary Operational Area, this area is the focus of the sub-sections below.

5.4.1 Sites of Significance

Ngāti Mutunga traditions illustrate their cultural, historical, and spiritual associations with the CMA. Such traditions represent links between the world of gods and present generations and reinforce tribal identify, connection and continuity between generations (TRC, 2018). The Taranaki coast has supplied Ngāti Mutunga with a constant supply of food resources; the coastal reefs provide koura, paua, kina, kutae, pupu, papaka, pipi, tuatua and many other reef species, while hapuka, moki, kanae, mako, patiki and Tamure swim between the reefs (TRC, 2018). Traditional names such as Onepoto, Waitoetoe, Waikiroa, Paparoa, Kukuriki, and Owei depict the whereabouts of fishing grounds or reefs (TRC, 2018). Mako, Tamure, kahawai and araara were caught off the papa rock cliffs, with titi, karoro (sea gull), and korora (penguin) also harvested from the cliffs.

The people of Ngāti Mutunga were often cremated, with many of the sites jutting out into the sea considered tapu as they were sites used for the cremation ritual. Many Ngāti Mutunga tupuna also lie buried along the coast (TRC, 2018).

Schedule 6B of the PCP (TRC, 2018) identifies known sites with special cultural, spiritual, historical and traditional associations within the CMA. The sites of significance within the rohe of Ngāti Mutunga are provided in **Table 12**. It must be stressed that **Table 12** does not represent an exhaustive list and due to the importance of many sites to Māori, sites are often not shared within the public domain. Therefore, the values of kaitiakitanga and mauri apply to all sites (TRC, 2018).

Table 12 Sites of Significance Areas within the rohe of Ngāti Mutunga

Area and sites of significance within the CMA	Overview of coastal area	Values associated with sites
Coastal Marine Area – Whakarewa Pā, Ruataki Pā/garden, Ruataki 2 Pā, Pā, Arapāwa Pā 1, 2 and 3, Whakaahu Pā, Pukekohe Pā, Pukekohe Pā/midden, Te Mutu o Tauranga Pā/midden/spring, Oropapa Pā, Maruehi Pā, Wahapakapaka kāinga/garden, Otamaringa Pā, middens, Arapāwa, Whakaahu, and Otamaringa Tauranga Waka, urupā, Kukuriki pūkāwa, Paparoa pūkāwa, Waitoetoe pūkāwa, Maru'ehi pūkāwa, and Pakihi pūkāwa.	Coastal area adjacent to the land from Titoki ridge to right bank of Waiau Stream. The resources within the CMA have, since time immemorial, provided Ngāti Mutunga with a constant supply of food resources. Ngāti Mutunga developed several ways of preserving resources for later consumption, using every part of the fish and this tradition continues to be used as a form of aroha koha at special hui. Ngāti Mutunga has and continues to exercise customary rights on the coastline and continues to gather food according to the values and tikanga of Ngāti Mutunga. There remain important kaitiaki links to the patiki, koura and tāmure breeding grounds as well as other fish resources. One of the kaitiaki responsibilities that Ngāti Mutunga traditionally filled and has continued to the present day is to protect the mouri of the coast and rivers. Ngāti Mutunga has exercised custondianship over the CMA by imposing rahui when appropriate – proper and sustainable management of the CMA has always been at the heart of the relationship between Ngāti Mutunga and the CMA.	Wairuatanga Historic site Access

Area and sites of significance within the CMA	Overview of coastal area	Values associated with sites
Onaero River – Puketapu/Pukemiro Pā, Onaero Tauranga Waka, Onaeroa River	The river was important to Ngāti Uenuku (also known as Ngāti Tupawhenua). Kaitangata also has a strong association with the river. The river and its banks have been occupied by the tupuna of Ngāti Mutunga since before the arrival of the Tokomaru and Tahatuna waka. Puketapu and Pukemiro pā are situated at the mouth of the river and other pā along the river include Pukemapou, Moerangi, Te Ngaio, Tikorangi, Kaitangata and Ruahine. Ngāti Mutunga used the entire length of the river for food gathering, with the river mouth providing pipi, Pūpu, patiki, kahawai and other fish. Inganga were caught along the riverbanks. The river was a spiritual force for the ancestors of Ngāti Mutunga and remains so today. There are specific areas of the river where people would bathe when sick. The river was used for tohi – such as for the baptism of babies.	Wairuatanga Historic site Access Mahinga kai Fishing Whitebaiting
Urenui River – Pohukura Pā, Kumara kai amo Pā, kāinga, Pohukura, Urenui, Papatiki, and Wai-iti Tauranga Waka	Traditionally the river (as associated wetland) have been a source of food and a communication waterway. A large number of pā are present along the riverbank and as a result the riverbank became the repository of many kōiwi. Pā included Pihanga, Phokura, Maruehi, Urenui, Kumarakaiamo, Ohaoko, Pā-oneone, Moeariki, Horopapa, Te Kawa, Pā-wawa, Otumoana, Orongowhiro, Okoki, Pukewhakamaru, and Tutumanuka. The entire river was used for food gathering, with the river mouth providing pipi, pūpu, patiki, kahawai and other fish. The river has always been an integral part of the social, spiritual and physical lifestyle of Ngāti Mutunga. Mouri is a critical element of the spiritual relationship to the river. The river was used for tohi – such as for the baptism of babies. Sick and those with skin conditions were taken to the river to be healed.	Mahinga kai Fishing Whitebaiting Wairuatanga Access
Mimitangiatua River – Arapāwanui Pā, Wairoa Kāinga, Wairoa Tauranga Waka, Mimitangiatua River, Tauranga Ika	The Mimi River has always been an integral part of the social, spiritual and physical lifestyle of Ngāti Mutunga. There are several Pā and kāinga located along the banks of the river – Mimi-Papahutiwai, Omihi, Arapawanui (the pā of Mutunga's grandsons Tukutahi and Rehetaia), Oropapa, Pukekohe, Toki-kinikini and Tupari. The river and associated huhi (swampy valleys), ngahere (large swamps) and repo (muddy swamps) were used by Ngāti Mutunga to preserve taonga. The whole length of the river was used for food gathering. Mouri is a critical element of the spiritual relationship of Ngāti Mutunga whanau to the Mimi River. The river is of the utmost importance because of its physical, spiritual and social significance in the past, present and future.	Wairuatanga Historic Site Access Mahinga Kai Whitebaiting Fishing
Wai-iti/Papatiki Stream – Paptiki and Wai-iti Tauranga Waka	Contains come significant pā sites including Ruataki, Pukekarito, and Whakarewa. Regular Runanga were held in the area of Wai-iti. The Papatiki Stream is tapu to Ngāti Mutunga because of the way in which it was used by northern invaders after a battle in pre-Pakeha times.	Wairuatanga Access
Waiau Stream	The stream is important as it marks the southwestern boundary of the Ngāti Mutunga rohe with Te Atiawa.	

Source: TRC, 2018
Wairuatanga = the practise of Māori spirituality
Mahinga kai = areas from which food resources are gathered and/or propagated

Te Atiawa's social, cultural and spiritual relationship with the CMA is very important and long-standing, beginning with the first Te Atiawa tupuna and has continued through the centuries to the present day. This relationship with the CMA is seen in the various sites of significance to Māori within the CMA, including those listed in Schedule 6B of the PCP, being the Motunui pūkāwa, Otaikokako Reef, Ukumokomoko Reef, Paparoa Reef, Pukotori Reef, Kawaroa Reef, Te Kawau/Kai-arohi Reef, Arakaitai/Otauanga Reef, Wahitapu Stream, Waiwhakaiho River, Te Hēnui Stream, Hongihongi Stream, Tutu Stream (these pūkāwa/reefs/rivers/streams as places for mahinga kai), Autere Tauranga waka (historic site), Parahuka Wahi Tapu (historic site) (TRC, 2018).

5.4.2 Customary Fishing and Iwi Fisheries Interests

Kaimoana provides sustenance for tangata whenua, it is an important food source for whānau and is vital for provision of hospitality to manuhiri (guests). Traditional management of the marine environment entails a whole body of knowledge on the sea's natural resources, their seasonality and the manner in which they can be harvested. This customary wisdom is held sacred by tangata whenua and is only passed on to those who will value it. The importance of each species of kaimoana varies between iwi/hapū, which is also based on what kaimoana species live and grow within and surrounding their rohe.

Under the Māori Fisheries Act 2004, recognised iwi were allocated fisheries assets (i.e. fishing quota). Each iwi was also assigned income shares in Aotearoa Fisheries Limited, which is managed and overseen by Te Ohu Kai Moana (the Māori Fisheries Commission). Te Ohu Kai Moana harvest, procure, farm, process, and market kaimoana in New Zealand and internationally. For quota associated with fisheries that are classified as 'deepwater', all iwi were assigned quota based on population size and relative length of coastline within their rohe. Quota for fisheries considered to be 'inshore' was allocated only to iwi whose rohe overlapped with the management area of the stock.

Separate from and in addition to commercial fisheries assets provided under the Māori Fisheries Act 2004, iwi hold customary fishing rights under the Fisheries (Kaimoana Customary Fishing) Regulations 1998. These regulations stem from the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 and provide for the customary harvesting of kaimoana for special occasions. Under these regulations' iwi may issue permits to harvest kaimoana in a way that exceeds levels permitted in standard practice in order to provide for hui (a gathering or meeting), tangi (funeral) or as koha (a gift, donation or contribution). The sale of any kaimoana harvested under the customary permit is prohibited. Only iwi may authorise a permit within their rohe moana, although the applicant/holder of a customary permit does not have to be affiliated to any iwi.

The allocation of customary fishing rights is undertaken by Tangata Kaitiaki/Tiaki in accordance with tikanga Māori. Tangata Kaitiaki/Tiaki are individuals or groups that have been appointed by local Tangata Whenua and confirmed by the Minister of Fisheries whose role is to authorise customary fishing with their rohe moana. Under the regulations, customary fishing rights can be caught by commercial fishing vessels on behalf of the holder of the customary fishing right. Customary fishing rights are in addition to recreational fishing rights and do not remove the right of Tangata Whenua to catch their recreational limits under the amateur fishing regulations.

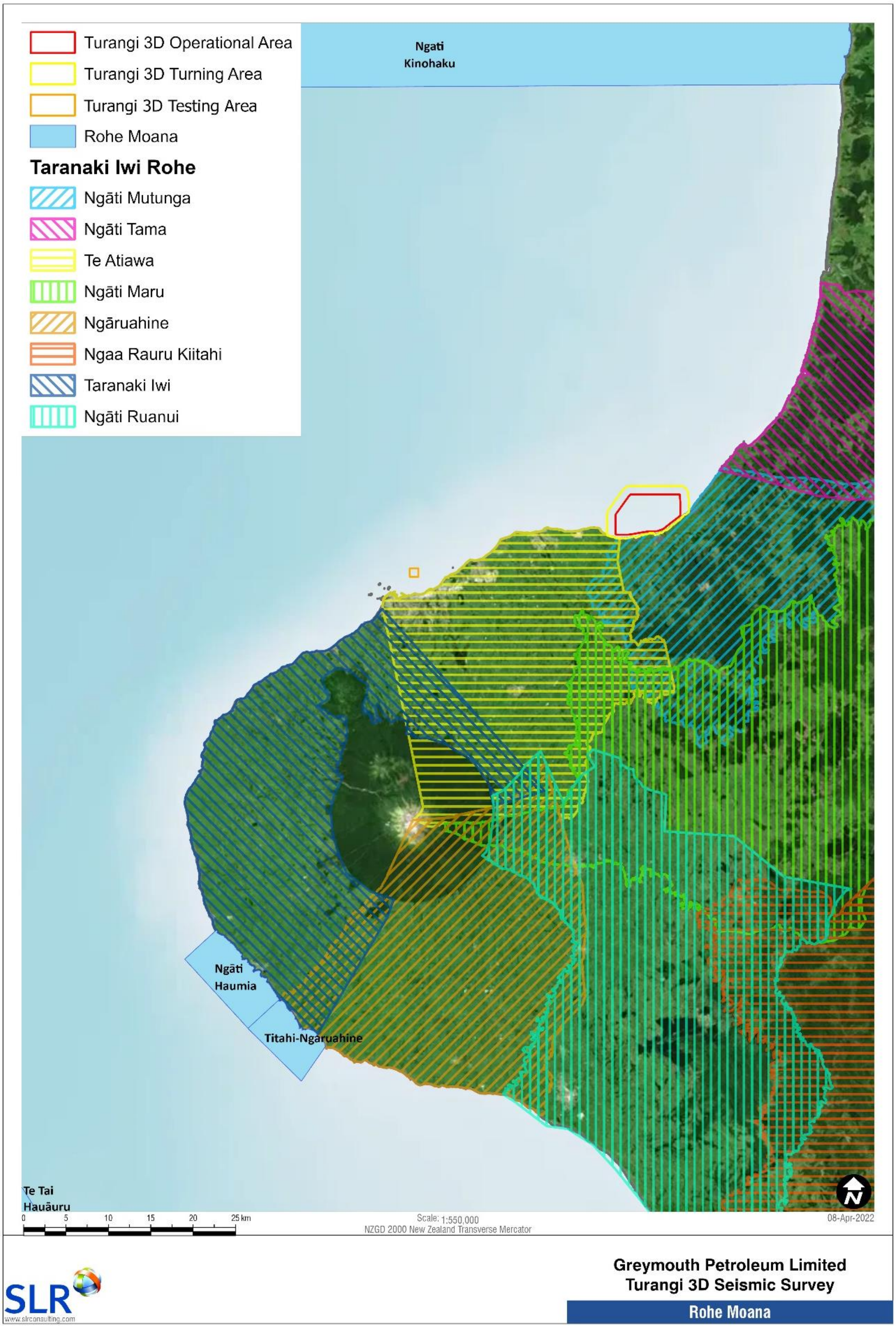
In addition to the above, the Fisheries (Amateur Fishing) Regulations 2013 imposes restrictions on the taking fish, aquatic life, or seaweed, unless they are taken for the purposes of a hui or tangi and are in accordance with an authorisation issued under regulation 51 of the Fisheries (Amateur Fishing) Regulations 2013.

There are three types of customary fishing rights recognised under the legislation: rohe moana, Mātaitai and Taiapure. There are no rohe moana, Mātaitai or Taiapure of relevance to the Primary Operational Area or Testing Area. However, the Primary Operational Area is of relevance to Ngāti Mutunga due to its location directly offshore of the rohe of Ngāti Mutunga and the testing area is relevant to the rohe of Te Atiawa (**Figure 13**).

5.4.2.1 Te Taihauāuru Forum

The Te Taihauāuru forum covers the western side of the lower North Island from the Mokau River south to Waikanae; an area known to iwi as the ‘rohe of Te Taihauāuru’. The goal of this forum is to collaborate on fisheries management issues for the benefit of present and future generations while recognising and providing for traditional relationships of iwi and their customary interests (Te Taihauāuru, 2012). Members of the forum include the Te Atiawa (Taranaki) Settlements Trust, Te Rūnanga o Ngāti Mutunga, Te Kaahui o Ruru, Te Rūnanga o Ngāi Apa, Te Whiringa Muka Trust, Ati Awa Ki Whaarongotai Charitable Trust, Muaupoko Tribal Authority Inc., Te Rūnanga o Raukawa/Raukawa Ki Te Tonga Trust, Te Pātiki Trust – Ngāti Hauiti, and Te Ohu Tiaki o Rangitāne Te Ika a Māui Trust. The fisheries plan, ‘Te Taihauāuru Iwi Forum Fisheries Plan 2012 – 2017’, outlines the collective agreements of the iwi involved, with a secondary purpose of identifying how government and private organisations can work in with Te Taihauāuru to assist in achieving their objectives.

Figure 13 Rohe of relevance to the Primary Operational Area and Testing Area



5.4.3 Interests under the Marine & Coastal Area (Takutai Moana) Act 2011

The Marine and Coastal Area (Takutai Moana) Act 2011 acknowledges the importance of the marine and coastal area to all New Zealanders while providing for the recognition of the customary rights of iwi, hapū and whānau in the CMA. Iwi, hapū or whānau groups may be granted recognition of two types of customary interest under the Marine and Coastal Area Act: Customary Marine Title and Protected Customary Rights. The recognition that these two types of customary interest provide were summarised by the Department of Justice (Te Arawhiti, 2020), as outlined below.

Customary Marine Title recognises the relationship of an iwi, hapū, or whānau with a part of the common marine and coastal area. Public access, fishing and other recreational activities are allowed to continue in Customary Marine Title areas; however, the group that holds Customary Marine Title maintains the following rights:

- A 'Resource Management Act permission right' allowing the group to say yes or no to activities that need resource consents or permits in the area;
- A 'conservation permission right' allowing the group to say yes or no to certain conservation activities in the area;
- The right to be notified and consulted when there is an application for a marine mammal watching permit in the area;
- The right to be consulted about changes to relevant Coastal Policy Statements;
- A wāhi tapu protection right allows the group to seek recognition of a wāhi tapu and restrict access to the area if required to protect the wāhi tapu;
- The ownership of minerals other than petroleum, gold, silver and uranium found in the area;
- The interim ownership of taonga tūturu found in the area; and
- The ability to prepare a planning document that sets out the group's objectives and policies for the management of resources in the area.

Protected Customary Rights may be granted within the CMA to allow for customary activities such as the collection of hāngi stones or launching of waka. If a group has a Protected Customary Right recognised, they do not need resource consent to carry out that activity and local authorities can't grant Resource Consents for other activities that would have an adverse effect on the Protected Customary Right.

Table 13 lists the Customary Marine Title and Protected Customary Rights applications that have been received and are of relevance to the Primary Operational Area and Testing Area. These applications are still being progressed and no official approval has been released.

Table 13 Applications under the Marine and Coastal Area (Takutai Moana) Act 2011 in the vicinity of the the Primary Operational Area and Testing Area

Applicant	High Court Reference	Recognition Sought	Application Area
Ngāti Mutunga	CIV-2017-485-215	Customary Marine Title and Protected Customary Rights	Titoki Ridge to the Esplanade Reserve out to 12 NM.
Ngati Tama	CIV-2017-404-534	Customary Marine Title and Protected Customary Right	Ngāti Tama rohe and out to 12 NM – map provided in application, but boundary point not specifically named.

5.5 Socio-Economic Environment

This section outlines the socio-economic environment within and in close proximity to the Primary Operational Area and Testing Area. This section covers fisheries (recreational and commercial), shipping, and oil and gas activities.

5.5.1 Fisheries

Fishing in New Zealand's coastal and EEZ waters can be spilt into three main parts; Commercial fishing, traditional/customary fishing, and recreational fishing.

There are ten Fisheries Management Areas (**FMA**) implemented within New Zealand waters that have been established to manage the Quota Management System (**QMS**). The QMS is currently regulated by Fisheries New Zealand (**FNZ**) and is the primary management tool to allow commercial utilisation of New Zealand's fisheries resources while ensuring their sustainability for the future; the QMS and Annual Catch Entitlements provide for the commercial utilisation and sustainable catch of 96 species.

The Primary Operational Area and Testing Area lie within FMA 8 (Central). FMA 8 covers the Taranaki and Whanganui coastline, where the exposed coastline is subject to westerly winds and southwest swells, which can often result in rough seas and limit the number of fishable days. Despite the exposed nature of the coastline, the area is considered to have a valuable recreational, customary and inshore commercial and offshore trawler fishery. FNZ has rated the customary and recreational significance and the environmental importance of this area and considers that it is high (FNZ, 2021).

Fishing within the coastal waters of the Primary Operational Area and Testing Area is restricted under the Fisheries Act 1996 to avoid, remedy, or mitigate the effect of fishing-related mortality on any protected species, as follows:

- Recreational and commercial set-net prohibition from Maunganui Bluff to Waiwhakaiho River out to 12 NM offshore, as well as the area between Waiwhakaiho River and Hawera going out to 7 NM;
- Commercial trawl prohibition from Maunganui Bluff to Waiwhakaiho River out to 4 NM offshore; and
- Commercial and recreational drift netting is banned in its entirety in all New Zealand waters.

5.5.1.1 Recreational Fisheries

Recreational fishing is one of New Zealand's most popular pastimes; in a recent nationwide recreational fishing survey, the National Research Bureau Limited reports that approximately 248,000 New Zealanders fish (Wynne-Jones *et al.,* 2019). The most frequent method of fishing is by rod or line from a trailer boat, followed by fishing with a rod or line from land. The most commonly harvested finfish species (determined by weight) in FMA 8 was blue cod, kahawai, pilchard, red gurnard, snapper and tarakihi (Wynne-Jones *et al*., 2019).

Sea conditions within the North Taranaki Bight are often rough; however, recreational fishers take advantage of clam weather periods to fish for inshore species such as snapper and trevally, with boats venturing further out in summer months to target large sport fish such as tuna and marlin. Long-lining using kontikis and kites as well as surfcasting is popular along the surf beaches (FNZ, 2021).

5.5.1.2 Commercial Fisheries

The wider FMA 8 supports a mixed trawl fishery for snapper, gurnard, tarakihi, trevally, and white warehou, with commercial set netting for rig and school shark, longlining for snapper, and potting for rock lobster also occurring (FNZ, 2021). Due to the restrictions imposed on commercial fishers within North Taranaki waters and the area protected by the West Coast North Island Marine Mammal Sanctuary, any commercial fishing that occurs within the Primary Operational Area and Testing Area (inshore FMA 8) will be associated with the long-line fishery.

5.5.2 Commercial Shipping

MNZ recommends commercial vessels should stay a minimum of 5 NM off the mainland, any charted points of danger, or any offshore islands; as such commercial shipping will not occur within the Primary Operational Area; however some shipping will occur in and around the Testing Area.

In 2007 the International Maritime Organisation established the Taranaki Offshore Precautionary Area (**Figure** 14). All ships passing through this area must navigate with caution in order to reduce the risk of a maritime casualty and the possible resulting marine pollution, given the high level of offshore petroleum activity within the area. The Precautionary Area is a standing notice in the Notice to Mariners issued by LINZ each year in the New Zealand Nautical Almanac. The Primary Operational Area lies within the Precautionary Area due to its proximity to the Pohokura field.

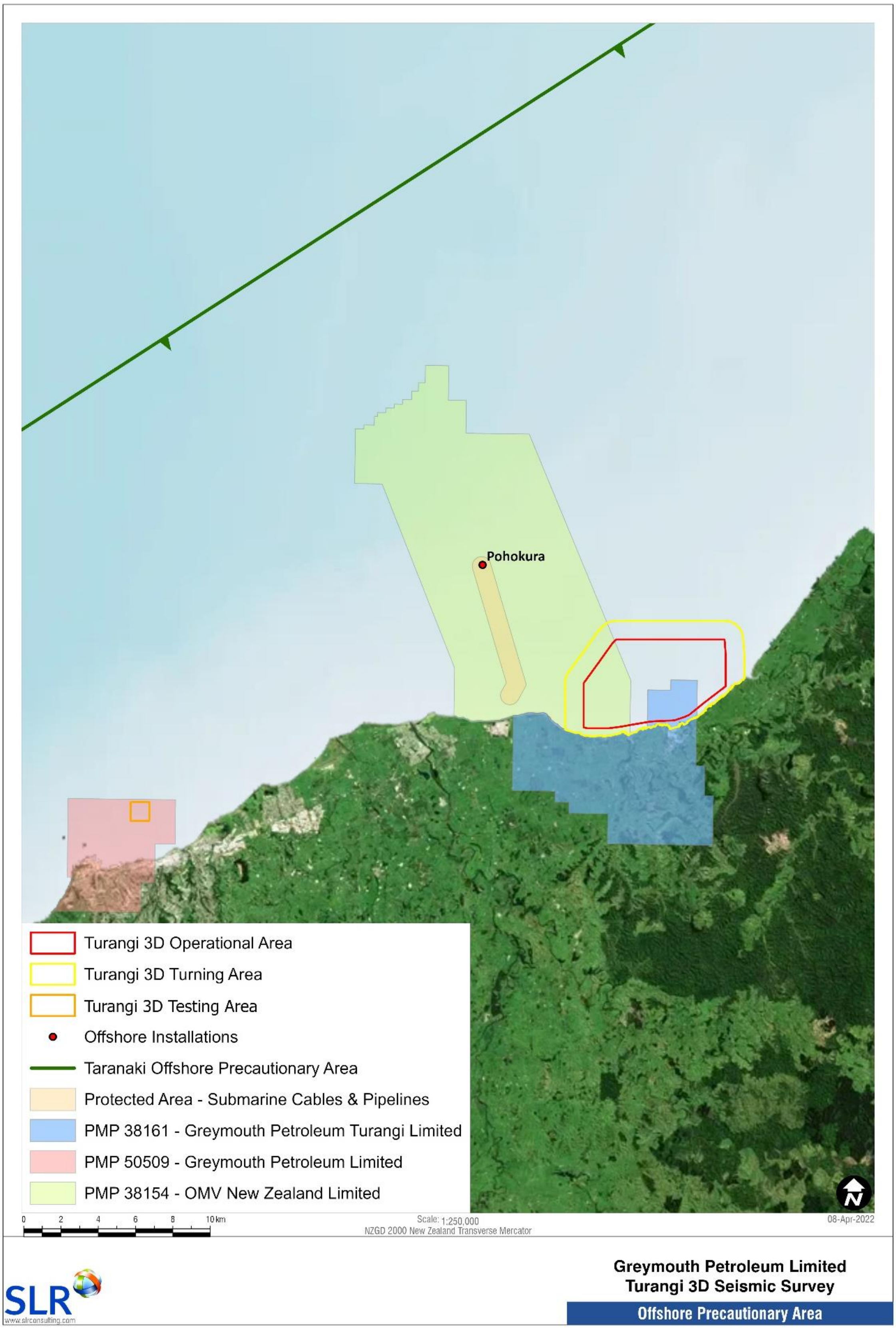
Commercial shipping will be higher in the vicinity of the Testing Area due to its relatively close proximity to Port Taranaki (approximately 2 km to the west). Port Taranaki is the only deep-water major seaport on the western coast of New Zealand. It caters to a wide variety of vessels and cargoes with a maximum draft of 12.5 m, and provides a full range of providoring, stevedoring, ship agency, customs and border protection services (Port Taranaki, 2021). Most vessel traffic through the port relates to the farming, engineering, and oil and gas industries. Port Taranaki has been the main base for oil and gas industries since the beginning of the offshore and onshore exploration and production activities in New Zealand.

5.5.3 Oil and Gas Activities

Hydrocarbon exploration has occurred off the coast of Taranaki since the 1960s, with production of gas, condensate, oil and associated products since 1979. The Taranaki region is the centre of New Zealand's oil, gas and petrochemical industries, and with the significant economic input the industry and associated support industries contribute, oil and gas are of major importance to the New Zealand economy.

As shown in **Figure 14**, the Primary Operational Area lies in the vicinity of the Pohokura Gas Field and associated platform and pipelines. As identified in **Section 5.3.2.3**, the Pohokura filed is protected by the Pohokura Submarine Cable Closure.

Figure 14 Taranaki Offshore Precautionary Area and Pohokura gas field



6 Potential Environmental Effects and Mitigation Measures

This section presents an overview of the potential environmental effects that may arise from the operation of the Turangi 3D Seismic Survey. Effects could occur under normal operating situations (i.e. planned activities), or during an accidental incident (i.e. unplanned events). Proposed mitigation measures are provided throughout the relevant sections.

6.1 Environmental Risk Assessment Methodology

The following steps were followed in order to assess the significance of potential effects from the Turangi 3D Seismic Survey:

- Identification of the sources of potential effects (both positive and negative);
- Description of potential effects;
- Identification of the key potential environmental receptors and their sensitivity to potential effects;
- Description of mitigation measures that will be employed to minimise potential effects; and
- Assessment of the significance of any residual effects. This assessment considers the likelihood and magnitude of any residual effect in relation to the sensitivity of each environmental receptor. The ‘Assessment of Significance’ criteria used for residual effects are provided in **Table 14**.

Table 14 Assessment of significance of residual effects

Negligible Effect
• No residual effects are predicted; or • The risk of residual effects occurring is extremely low; and • The effect is predicted to be of small enough magnitude that it does not require further consideration, and no recovery period is required.
Minor Effect
• The risk of residual effects occurring is low; and/or • The residual effect is predicted to disappear rapidly (within hours) after cessation of the causative activity. • No further management measures are required for the return to the original situation or behaviour.
Moderate Effect
• The risk of residual effects occurring is moderate; and/or • The residual effect is predicted to occur at a level which requires only a short period of recovery (up to 24 hours) following cessation of the activity. • No further management measures are required for the return to the original situation or behaviour. • For acoustic effects on marine mammals, this effect is likely to occur when exposed to sound levels up to 171 dB re 1 $\mu Pa^2 \cdot s$; i.e. behavioural changes and masking are possible, but no threshold shifts will occur.
Major Effect
• The risk of residual effects occurring is high; and/or • The residual effect is predicted to occur at a level which requires a long period of recovery (greater than 24 hours) following cessation of the activity. • For acoustic effects on marine mammals, this effect is likely to occur when exposed to sound levels between 171 – 186 dB re 1 $\mu Pa^2 \cdot s$; i.e. temporary threshold shifts are possible.
Severe Effect
• The risk of residual effects occurring is very high; and/or • The residual effect is predicted to occur at a level whereby no recovery is expected following cessation of the activity. • For acoustic effects on marine mammals this effect is likely to occur when exposed to sound levels greater than 186 dB re 1 $\mu Pa^2 \cdot s$; i.e. permanent threshold shift or other physiological damage is possible.

6.2 Planned Activities

6.2.1 Physical Presence of Survey Vessel and Ocean Bottom Acquisition System

Operation of the acoustic source will be carried out onboard the survey vessel. Hydrophones will be deployed in nodes on the seabed as described in **Section 2.2**. A support vessel will also be present for deployment of the ocean bottom acquisition system and acoustic positioning. Two MMOs and two PAM Operators will be positioned on the source vessel to conduct marine mammal observations in accordance with the Code of Conduct.

Potential effects arising from the physical presence of survey vessels and ocean bottom acquisition system are discussed below.

6.2.1.1 Potential Effects on Marine Mammals

When in the presence of vessels marine mammals tend to exhibit two stereotypical behaviours: avoidance or attraction (Wűrsig *et al*., 1998). Both responses can affect the animal's energy expenditure when they become distracted from engaging in natural behaviours such as feeding, resting, and socialising. Avoidance responses are more frequently documented than attraction responses and most commonly lead to animals becoming temporarily displaced from an area (Wűrsig *et al*., 1998). This is of particular concern when changes occur frequently over a prolonged period and/or when they affect critical behaviours (i.e. feeding, breeding and resting).

New Zealand fur seals are present in the Taranaki region and use the AOI for foraging or resting. Lalas and McConnell (2016) investigated the response of New Zealand fur seals to a large-scale offshore 3D seismic survey and found that the source vessel and towed gear created physical obstacles that generated responses from fur seals. The authors suggested that the acoustic source noise was not the only stimulus that generated a response from seals; with noise from the vessel engines or changes in wave pattern created by the vessel or towed gear also having an influence. When awake, seals also responded to the visual stimulus of vessel presence. Overall, Lalas and McConnell (2016) concluded that the vessel and towed gear create physical obstacles that generated the observed avoidance response rather than exposure to underwater noise. Fur seals typically forage at night and rest at the surface during daylight hours (Harcourt *et al*., 2001;2002). As NZSL will only operate the Turangi 3D Seismic during daylight hours, any disturbance to fur seals by the survey vessel and towed equipment is not anticipated to significantly affect foraging activities.

Bejder *et al*. (1999) investigated the effects of vessels associated with dolphin swimming tourism on the behaviour of Hector's dolphins in Porpoise Bay (Southland). The dolphins spent most daylight hours in an area confined by a small reef system and the surf zone of the southern end of the bay. Although most of the observed swim-with-dolphin attempts (57%, n=32) did not disturb dolphins (i.e. they remained nearby), approximately 30% (n=17) were potentially disturbing as dolphins left the area within a few minutes, while the remaining encounters (n=7) were disturbing with dolphins immediately leaving the area (Bejder *et al*., 1999). Dolphins were attracted to the noise of boats within the first 10 minutes of the encounter and approached the boat less frequently as the encounter duration increased (Bejder *et al*., 1999).

It is important to note that although Bejder *et al*. (1999) indicated that some displacement occurred in Hector's dolphins (and therefore potentially Māui's dolphins), swim-with-dolphin vessels actively approach groups of dolphins. The survey vessel will be operating along pre-determined lines and will not actively approach any marine mammal. The Primary Operational Area and Testing Area are not in an enclosed bay and any animal can freely move away from a disturbance. The presence of the survey vessel in the Primary Operational Area and Testing Area will be temporary (i.e. 21 days from node receiver deployment to receiver retrieval) and the area is already used by transiting vessels (e.g. recreational and commercial fishing boats).

'Ship strike' refers to the collision between a vessel and an animal and has been recognised internationally as an increasing conservation concern for marine mammals (IWC, 2014). Although the potential for ship strike is present in all areas where marine mammals and shipping overlap, the Turangi 3D Seismic Survey will not increase the risk of ship strike as the survey vessel will be operating at very slow speeds and within an area that does not support high densities of marine mammals. Cetacean species present within the Primary Operational Area and Testing Area are likely to be dolphins or small whales which due to their manoeuvrability are less vulnerable to ship strike. The speed of the survey vessel will increase when transiting to/from the Primary Operational Area and Testing Area, although the vessel master will comply with the Marine Mammal Protection Regulations 1992 when in the vicinity of marine mammals (e.g. reduced speed, restrictions to approach direction etc.) which will minimise any potential for ship strike.

Although the presence of the survey vessel may result in some disturbance to marine mammals, the Primary Operational Area and Testing Area are not considered to be of particular significance to marine mammals relative to other coastal habitat in the region and numbers of marine mammals within the AOI are not expected to be high. Data acquisition will only occur during daylight hours, increasing the visibility of marine mammals to those onboard the survey vessel and reducing the risk of a collision. Overall, it is considered that the significance of residual effects to marine mammals arising from the physical presence of the survey vessel during the Turangi 3D Seismic Survey is **negligible**.

6.2.1.2 Potential Effects on Seabirds and Little Blue Penguins

Seabird interactions with vessels are relatively common in marine waters. While most interactions are harmless, some can be detrimental and may cause injury or death (e.g. bird strike). Seabirds have been shown to respond to vessels by avoidance of heavily used areas and disruption of feeding behaviours (Schwemmer *et al.*, 2011; Velando & Munilla, 2011; Ronconi *et al*., 2015).

While the movements of the survey vessel through the Primary Operational Area and Testing Area may disturb seabirds (including little blue penguins), the area of potential displacement is small compared to the wider surrounding habitat. The survey vessel will be operating at low speeds while acquiring data for the Turangi 3D Seismic Survey and as such, it is expected that most seabirds in the vessel path will relocate to avoid collision as is typical of all inshore interactions between vessels and seabirds.

Little blue penguins are routinely observed diving out of the way of oncoming vessels and with the low operating speeds of the vessels associated with the Turangi 3D Seismic Survey, little blue penguins will be able to avoid any vessel strike. Vessel crew onboard the survey vessels will at all times remain vigilant for sightings of little blue penguins. Observations of little blue penguins will be included in daily observations and reported alongside the required marine mammal observations.

Overall, it is considered that the significance of residual effects to little blue penguins and seabirds arising from the physical presence of the survey vessel during the Turangi 3D Seismic Survey is **negligible**.

6.2.1.3 Potential Effects on Benthic Fauna

As discussed in **Section 2.2**, the Turangi 3D Seismic Survey will utilise an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system, will be employed for receiving the acoustic signal. The independent autonomous nodes which have internal hydrophones will be weighted with ropes and will be placed on the seabed. These will be positioned and location monitored through acoustic transponder. No mechanical burying of the nodes or excavation of the seabed is required. The ocean bottom acquisition system will be retrieved from the seabed at the conclusion of acquisition of all source points (both marine and land-based).

Depending on the substrate within the Primary Operational Area, the laying of the ocean bottom acquisition system on the seabed may cause a localised increase in suspended sediment when the system contacts the seabed and may result in the smothering or crushing of some fauna directly underneath the nodes, weights or tethers. Due to its location along Taranaki's high-energy coastal environment, the Primary Operational Area experiences high turbidity levels, and it is unlikely that a small increase in turbidity from the ocean bottom acquisition system will have any effect on the surrounding environment. Mobile fauna will be able to move out of the way of the nodes, and although sedentary or slow-moving animals may be crushed, no population-level effects are anticipated. Prior to deployment each receiver location will be checked to ensure that the nodes will be placed on the seabed away from any reef or rock outcrops where biodiversity values would be higher.

Due to the temporary and highly localised nature of potential effects, the significance of residual environmental effects to benthic fauna within the Primary Operational Area from the positioning of the ocean bottom acquisition system on the seabed has been assessed as **negligible**.

6.2.1.4 Potential Effects on Other Marine Users

The low use of the Primary Operational Area and Testing Area by other marine users, low speed of the survey vessel and relatively short duration of the Turangi 3D Seismic Survey means there is unlikely to be a hazard of collision and displacement of other marine users will be temporary.

NZSL have considered the normal influx of holiday makers to the Primary Operational Area and Testing Area and propose that acquisition occur immediately following the summer school holidays. This will allow initial phases to be completed with minimal impact to other marine users as recreational activities including fishing and recreational boating will reduce at this time. Any displacement of other marine users from around the ocean bottom acquisition system will be temporary as the system will be retrieved once acquisition is completed.

All vessels involved in the Turangi 3D Seismic Survey will comply with COLREGS (e.g. radio contact, day shapes, navigation lights, etc.). NZSL will only acquire seismic data within the Primary Operational Area during daylight hours, increasing the visibility of the survey vessel to other marine users.

Overall, the significance of the residual environmental effects to other marine traffic within the Primary Operational Area and Testing Area due to the presence of the survey vessel, or towed equipment and ocean bottom acquisition system is considered to be **negligible**.

6.2.2 Acoustic Disturbance to the Marine Environment

The acoustic source produces a predominantly low-frequency noise that is of short duration with high peak source levels. The acoustic pulses are directed downwards and propagate efficiently through the water column with little loss from attenuation (i.e. absorption and scattering). Upon activation of the acoustic source, the majority of the emitted energy is of low frequencies between 0.1 and 0.3 kHz; however, pulses also contain higher frequencies of 0.5 – 1 kHz, albeit in small amounts (Richardson *et al.*, 1995). The low-frequency component of the sound spectrum attenuates slowly, while the high-frequency component rapidly attenuates to levels similar to those produced by natural sources.

The acoustic pulse produces a steep-fronted wave that is transformed into a high-intensity pressure wave (i.e. a shock wave with an outward flow of energy in the form of water movement) resulting in an instantaneous rise in maximum pressure, followed by an exponential drop in pressure. The environmental effects on animals in the vicinity of a source are defined by individual interactions with these sound waves and can be grouped into the following categories:

- Physiological effects – e.g. changes in hearing thresholds, damage to sensory organs, or traumatic injury;
- Behavioural effects and related impacts – e.g. displacement/avoidance, startle response, disruption of feeding, breeding or nursery activities, etc.;
- Perceptual effects/auditory masking – interference with communication; and
- Indirect effects – e.g. behavioural changes in prey species that affects other species higher up in the food chain and could lead to ecosystem level effects.

A high-intensity external stimulus such as an acoustic disturbance will typically elicit a behavioural response in animals; usually avoidance or a change in behavioural state. The duration and intensity of the animal's response is impacted by the nature (continuous vs. pulsed noise), source (visual, chemical or auditory), and intensity of the stimulus, as well as the animal's species, gender, reproductive status, health and age. A behavioural response is an instinctive survival mechanism that serves to protect animals from injury. Consequently, animals may suffer temporary or permanent physiological effects on cases when the external stimulus is too high, or the animal is unable to elicit a sufficient behavioural response. Temporary or permanent physiological effects may also be incurred due to a behavioural response (e.g. getting the 'bends' from swimming quickly to the surface from depth).

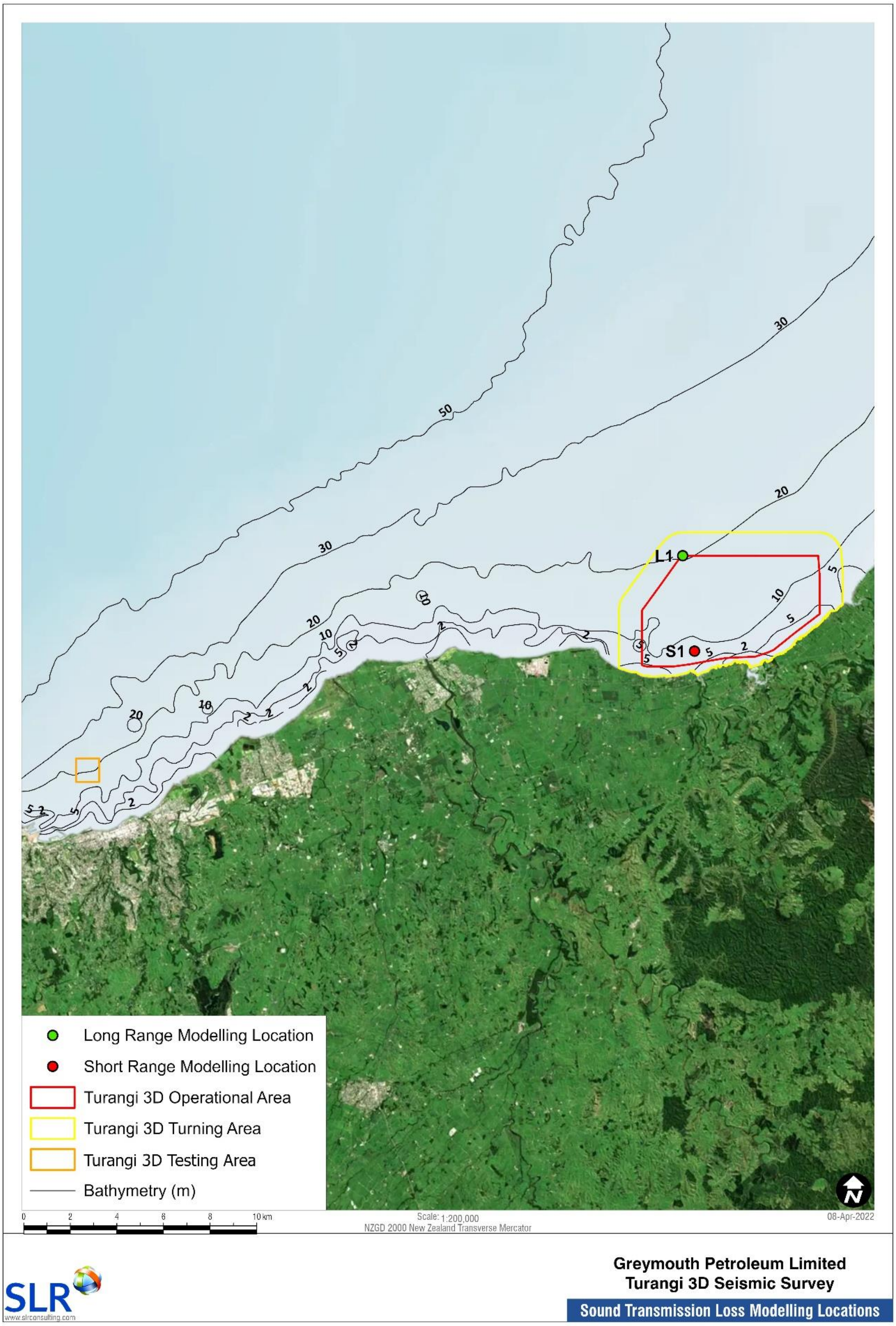
The Code of Conduct was specifically developed to minimise potential behavioural and physiological effects on marine mammals of acoustic disturbance from seismic surveys. Compliance with the Code of Conduct represents the primary way in which the potential effects of acoustic disturbance during the Turangi 3D Seismic Survey will be managed.

6.2.2.1 Sound Transmission Loss Modelling

The Code of Conduct requires STLM for any Level 1 survey that will occur within an Area of Ecological Importance or within a Marine Mammal Sanctuary. STLM uses input parameters specific to the source array, and site-specific bathymetry and geological data. SLR undertook STLM to predict received SELs from the Turangi 3D Seismic Survey to assess for compliance with the mitigation zones in the Code of Conduct. The modelling of the STLM addresses the horizontal and vertical directionality of the acoustic array and takes into consideration the water depth and substrate. The results of the modelling report are summarised below, with the complete report provided in **Appendix A**.

The continental shelf of New Zealand is mainly covered with land-derived sand, gravel, and mud sediments which have been predominantly introduced by riverine inputs. In order to predict the highest SELs possible during the Turangi 3D Seismic Survey, the worst-case environmental conditions were modelled, i.e. a winter seasonal sound speed profile and fine sand seabed sediment. A water depth of 10 m was chosen for the short range modelling scenario as this results in a worst-case assessment of potential noise effects. The deepest location within the survey area (i.e. water depth of approximately 20 m) was chosen for long range modelling scenarios. The modelled source locations for the two modelling scenarios are shown in **Figure 15**.

Figure 15 Short Range (S1) and Long Range (L1) Modelling Locations for the Primary Operational Area



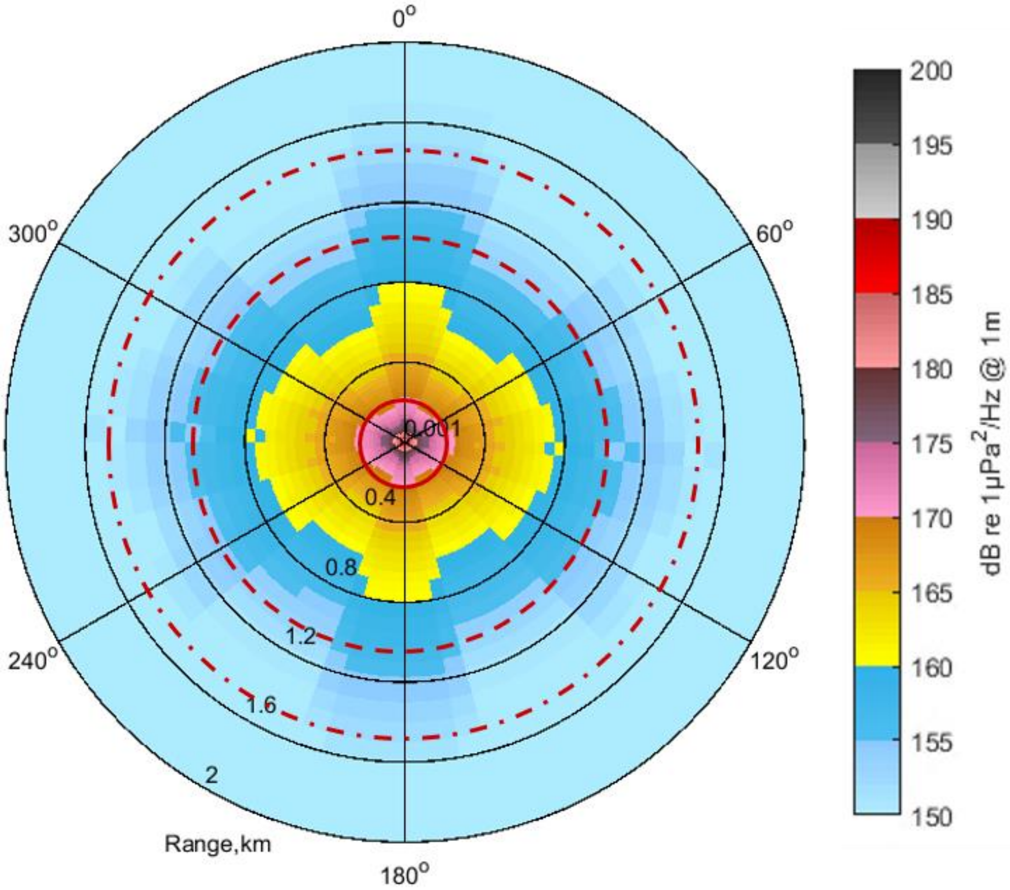
6.2.2.1.1 Modelling Results

Short Range Modelling Results

Short range modelling predicts the received SELs over a range of a few kilometres from the source location, in order to assess whether the proposed survey complies with the regulatory mitigation zones SEL requirements defined within the Code of Conduct.

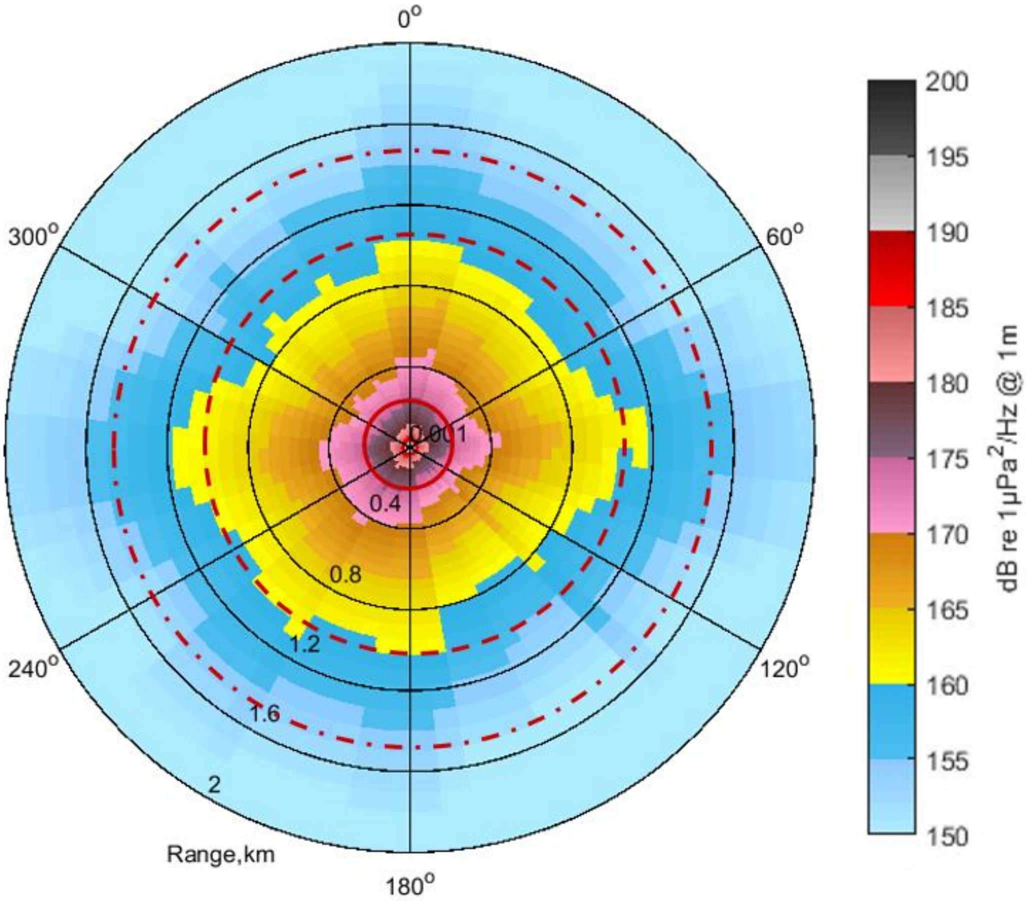
The results of the short range modelling are depicted in **Figure 16** and **Figure 17** for the 1,420 in^3 and 1,000 in^3 source volumes, respectively. These two figures depict the maximum received SELs across the water column as a function of azimuth and range from the centre of the array.

Figure 16 Predicted maximum received SELs across the water column as a function of azimuth and range from the centre of the 1,420 in^3 total source volume



Note: Dark red circles represent the mitigation zones of 200 m (solid), 1.0 km (dash), and 1.5 km (dash-dot).

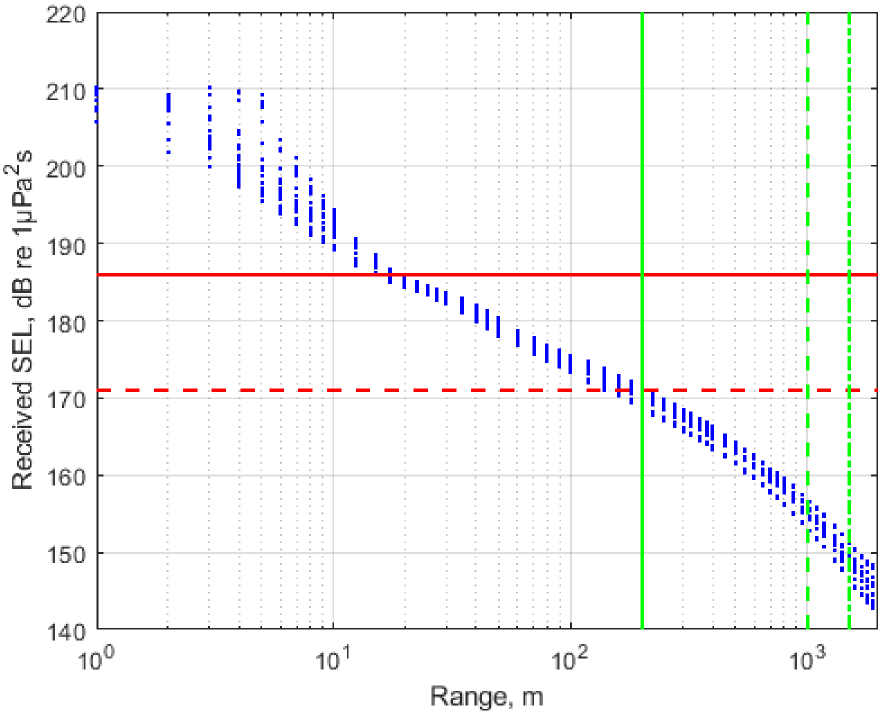
Figure 17 Predicted maximum received SELs across the water column as a function of azimuth and range from the centre of the 1,000 in^3 total source volume



Note: Dark red circles represent the mitigation zones of 200 m (solid), 1.0 km (dash), and 1.5 km (dash-dot).

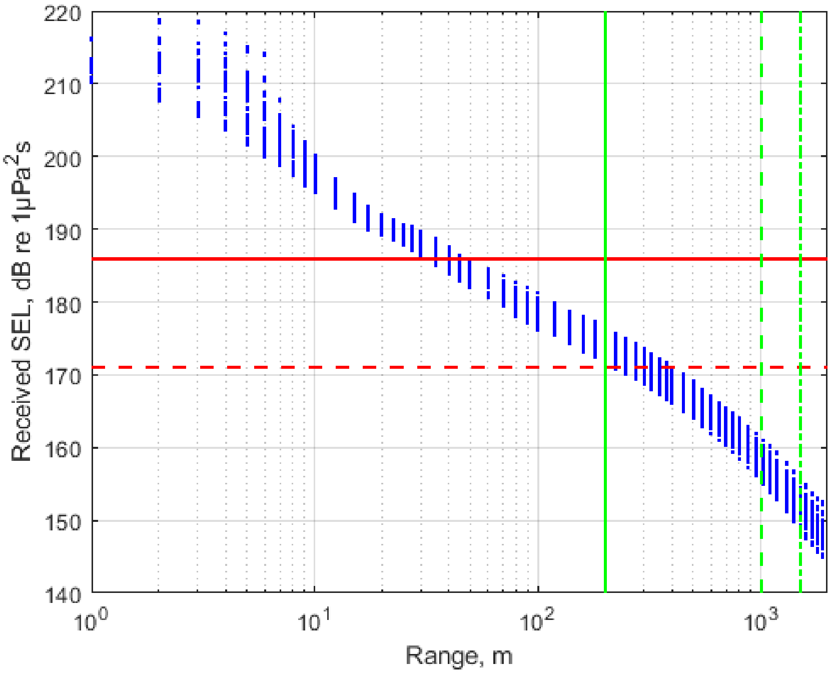
The scatter plots shown as **Figure 18** and **Figure 19** depict the maximum SEL across the water column from the source array from the centre of the acoustic source for the 1,420 in^3 and 1,000 in^3 source volumes, respectively. The PTS (186 dB re 1 μPa^2·s) and TTS (171 dB re 1 μPa^2·s) mitigation threshold levels and Code of Conduct mitigation zones (200 m PTS mitigation zone, and 1.0 km and 1.5 km TTS mitigation zone for species of concern with and without calf present respectively) are also shown in these two figures.

Figure 18 Scatter plot of maximum received SELs from the 1,420 in^3 total source volume



Note: Horizontal red lines show mitigation thresholds of 186 dB re 1 µPa^2·s (solid) and 171 dB re 1 µPa^2·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Figure 19 Scatter plot of maximum received SELs from the 1,000 in^3 total source volume



Note: Horizontal red lines show mitigation thresholds of 186 dB re 1 µPa^2·s (solid) and 171 dB re 1 µPa^2·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

The modelling results are summarised in **Table 15.** The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are provided in **Table 16.**

The results provided in **Table 15** demonstrate that the maximum received SELs from the Turangi 3D Seismic Survey within the Primary Operational Area are predicted to be below 186 dB re 1 µPa^2·s at 200 m and below 171 dB re 1 µPa^2·s at both 1 km and 1.5 km.

Table 15 Predicted maximum SEL for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the array for both arrays at source location S1.

Source Array	SEL at different ranges, dB re 1µPa^2·s		
	200 m	1.0 km	1.5 km
	(threshold level 186 dB re 1µPa^2·s)	(threshold level 171 dB re 1µPa^2·s)	
1,420 in^3	172	157	151
1,000 in^3	177	161	156

Table 16 presents the ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds. For the 186 dB re 1 µPa^2·s threshold the distances are 20 m and 50 m for the for the 1,420 in^3 and 1,000 in^3 source volumes, respectively. For the 171 dB re 1 µPa^2·s threshold the distances are 220 m and 400 m for the 1,420 in^3 and 1,000 in^3 source volumes, respectively.

Table 16 Ranges from the centre of the array where the predicted maximum SEL for all azimuths equals the SEL threshold levels for the source arrays at source location S1.

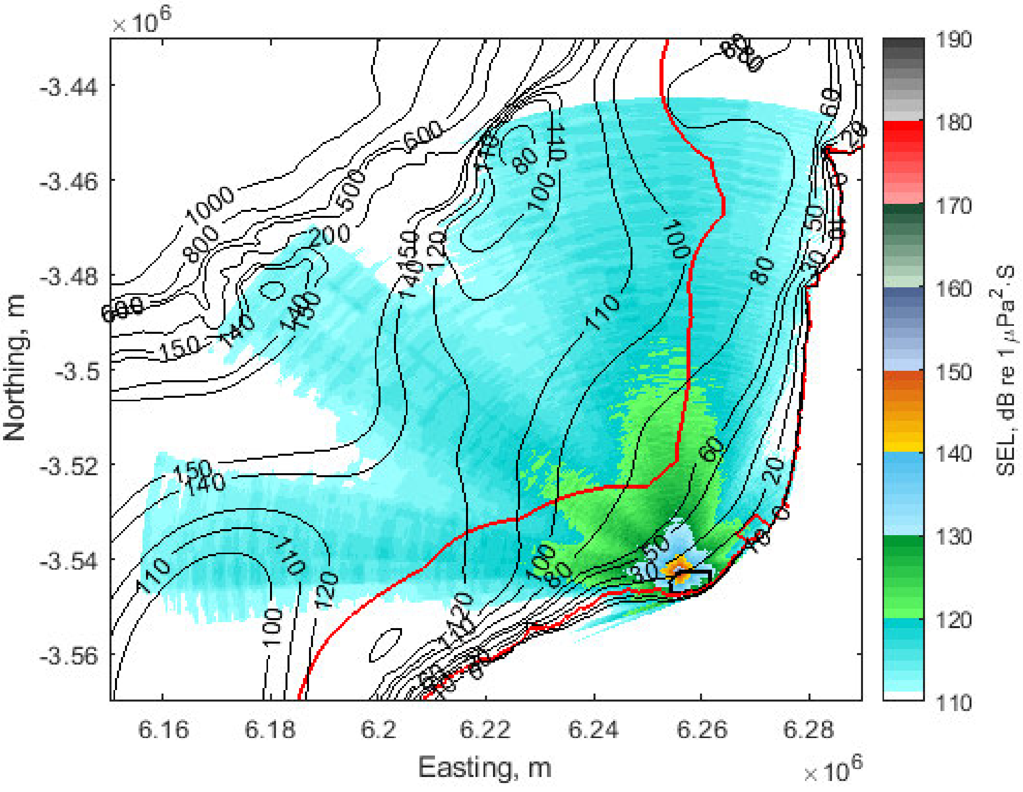
Source Array	Ranges complying with the following SEL thresholds, m	
	SEL < 186 dB re 1µPa^2·s	SEL < 171 dB re 1µPa^2·s
1,420 in^3	20	220
1,000 in^3	50	400

Long Range Modelling Results

Long range modelling predicts the received SELs over a range of tens to hundreds of kilometres from the array source location. Received SELs at far-field locations vary significantly with angle and distance from the source due to the directivity of the source array, and propagation effects caused by bathymetry, seabed reflectivity and variations in the sound speed profile. **Figure 20** and **Figure 21** show the maximum SEL experienced at far-field locations for the for the 1,420 in^3 and 1,000 in^3 total source volume scenarios, respectively.

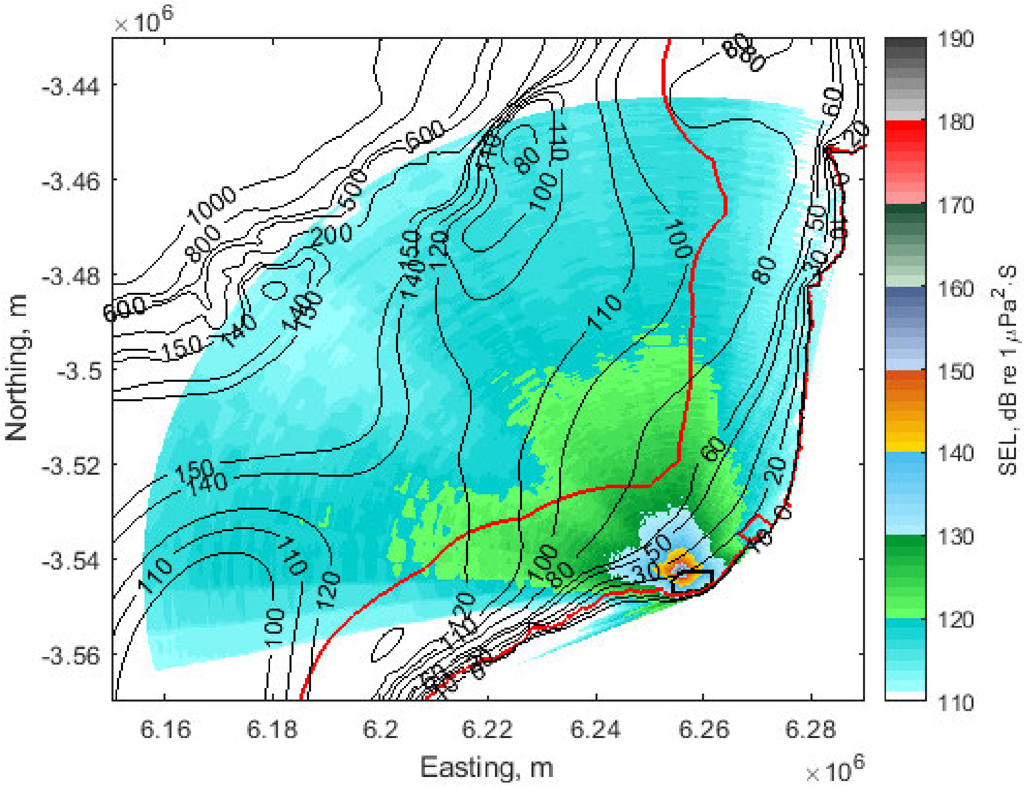
When travelling 'up slope' (i.e. from deep to shallow water), sound energy attenuates rapidly due to a strong interaction with the upslope seabed. When travelling in the offshore direction, sound energy initially interacts with the downslope seabed and then is predominantly trapped within the surface sound duct with the increase in depth. As a result, the sound energy experiences limited energy loss due to less interaction with the sea surface and seabed. At cross-line directions to the north and the east (i.e. offshore from the source location), the received SELs are predicted to be up to 110 dB re 1 µPa^2·s at distances up to 100 km away from the source location. Given that the Turangi 3D Seismic Survey is planned to occur within the West Coast North Island Marine Mammal Sanctuary, elevated SELs will occur within the sanctuary, but SELs greater than 171 dB re 1 µPa^2 s will be restricted to within 400 m of the source, but noise from seismic operations will be audible over a large area. It is however noteworthy that the auditory bandwidth for Maui's dolphins occurs between 0.2 kHz and 180 kHz. In contrast, frequencies emitted by seismic sources are broadband, with most of the energy concentrated between 0.1 kHz and 0.25 kHz. Hence there is only a very small overlap between the two frequency ranges meaning that much of the underwater noise generated by seismic surveys is likely to be inaudible to Māui's dolphins.

Figure 20 Maximum SELs predicted from the source location L1 to a maximum range of 100 km overlaid with bathymetry lines for the 1,420 in^3 total source volume



Note: Operational Area is outlined in blue. Red polygon represents the West Coast North Island Marine Mammal Sanctuary.

Figure 21 Maximum SELs predicted from the source location L1 to a maximum range of 100 km overlaid with bathymetry lines for the 1,000 in^3 total source volume



Note: Operational Area is outlined in blue. Red polygon represents the West Coast North Island Marine Mammal Sanctuary.

6.2.2.2 Potential Physiological Effects

Intense underwater sound can cause lethal and non-lethal physiological trauma or injury in marine organisms (Gordon *et al*., 2003). Although the Code of Conduct outlines threshold levels aimed at protecting marine mammals from physiological effects, such impacts are not limited to marine mammals. Tissue damage to sensory organs from acoustic releases associated with seismic surveys has been experimentally studied in fish, cephalopods and invertebrates, while shifts in hearing thresholds have been experimentally observed in some small pinnipeds and small cetaceans and hypothesised based on observed effects in terrestrial animals.

The sections below discuss the potential for physiological effects (i.e. trauma or damage) to faunal groups.

6.2.2.2.1 Zooplankton

Zooplankton do not have hearing structures but are able to detect changes in surrounding pressure (Richardson *et al*., 2017). Until recently it was believed that exposure to acoustic emissions from seismic has no significant effects on zooplankton abundance or mortality (e.g. Pearson *et al.,* 1994; Parry *et al.,* 2002; Dalen *et al.,* 2007; Payne *et al*., 2009), with physiological effects only occurring at distances up to 5 m from the active source, and mortality out to 3 m (Booman *et al.,* 1996; Payne *et al.,* 2009). Other studies reported no adverse effects to zooplankton at an individual (e.g. Dalen & Knutsen, 1987; Bolle *et al*., 2012) or population (Saetre & Ona, 1996) level.

In contract, McCauley *et al*. (2017) provided evidence to suggest that seismic surveys may cause significant mortality to zooplankton populations. McCauley *et al.* (2017) found reductions in modelled zooplankton abundance within 509 – 658 m from the source, with the range of no impact on zooplankton abundance occurring at 973 – 1,119 m. Post-exposure there was two to three times more dead zooplankton and 100% mortality in krill larvae at all distances. Sonar backscatter showed a 'hole' in the plankton community up to 30 m deep that followed the prevailing track of the seismic source and was detectable from 15 minutes after exposure (McCauley *et al*., 2017).

In response to McCauley *et al*. (2017), the Australian Petroleum Production and Exploration Association commissioned CSIRO to model the potential local and regional impacts of a typical seismic survey in the Northwest Shelf of Australia based on the results of McCauley *et al.* (2017). The CSIRO study showed that although zooplankton populations were impacted out to 15 km within the seismic survey area, impacts were barely discernible within 150 km of the survey area, and there was no apparent effect at a regional scale. Following exposure, zooplankton populations rapidly recovered due to fast growth rates and the dispersal and mixing of individuals from inside and outside of the impacted region (Richardson *et al*., 2017).

In addition, in an independent review (IAGC, 2017) of the McCauley *et al*. (2017) study, the reviewers "*expressed the opinion that although the results of the study should be considered further, the data were not sufficient to support the conclusions offered by McCauley et al. (2017)".* Several shortcomings were identified by the reviewers. The results of the review were shared with the authors of McCauley *et al*. (2017) and the authors concurred with many of the shortcomings identified by the reviewers (IAGC, 2017).

The Primary Operational Area and Testing Area for the Turangi 3D Seismic Survey are considerably smaller than the area modelled by Richardson *et al.* (2017), the acoustic source will have a smaller volume (1,000 in^3 or 1,420 in^3 compared to 3,200 in^3), and the survey will be acquired over a shorter period of time (seven days of acquisition (over a total survey period of 21 days) compared to 35 days).

Recently, Fields *et al*. (2019) exposed the copepod *Calanus finmarchius* to acoustic releases from two acoustic sources with a combined total volume of 520 in^3. Immediate mortality was significantly different from controls at distances of 5 m or less, and mortality after one week was significantly higher at distances of 10 m from the acoustic source but not at distances of 20 m. Increase in mortality relative to the controls did not exceed 30% at any distance from the acoustic source. Fields *et al*. (2019) concluded that emissions from seismic activity have limited effects on the mortality or escape response of *Calanus sp*. within 10 m of the source and no measurable impact at greater distances. The findings of Fields *et al*. (2019) contradict those of McCauley *et al*. (2017) while supporting previous studies such as Booman *et al.* (1996) and Payne *et al.* (2009), whereby effects are limited to within a few tens of meters of the acoustic source.

The Primary Operational Area and Testing Area are not considered to be a hotspot for zooplankton, therefore although the potential for mortality of zooplankton during the Turangi 3D Seismic Survey cannot be dismissed, wide-ranging or population-level effects on zooplankton are unlikely. Movements of water masses from outside the disturbed zone will rapidly replenish any zooplankton populations that may have been depleted by acoustic disturbance.

Based on the discussion above, the significance of residual physiological effects on zooplankton populations due to acoustic disturbance from the Turangi 3D Seismic Survey is considered to be **minor**.

6.2.2.2.2 Benthic Invertebrates

Many marine invertebrates have sound-sensitive mechanoreceptors (sensory hairs or organs) which bear some resemblance to vertebrate ears. McCauley (1994) reported that for many benthic species these receptors will perceive seismic acoustic outputs but only within a few meters from the sound source.

The Royal Society of Canada (2004) reported that research has shown that macro-invertebrates (e.g. scallops, sea urchins, mussels, periwinkles, crustaceans, shrimp and gastropods) suffer very little mortality below sound levels of 220 dB re 1 µPa @ 1 m, while some show no mortality at 230 dB re 1 µPa @ 1 m. This resilience to sound exposure has been attributed to the lack of a swim bladder (Moriyasu *et al*., 2004).

Moriyasu *et al*. (2004) compiled a literature review of some early studies, the results of which are summarised below:

- There were no physiological effects detected in amphipods exposed to a seismic source with a source level of 223 dB re 1 µPa at distances of 0.5 m or greater (Dalen, 1994);
- No physiological effects were observed in blue mussels (*Mytilus edulis*) exposed to a seismic source with a source level of 223 dB re 1 µPa at distances of 0.5 m or greater (Dalen, 1994);
- There was no mortality or evidence of reduced catch rate for brown shrimp exposed to a source level of 190 dB re 1 µPa @ 1 m in water depths of 2 m (Webb & Kempf, 1998); and
- Shell damage associated with high intensity seismic exposure was recorded in one of three species of mollusc exposed to a source level of 233 dB re 1 µPa at a distance of 2 m (Matishov, 1992).

More recently, Carroll *et al*. (2017) undertook a review of the impacts of low-frequency seismic emissions on invertebrates. Carroll *et al.* (2017) stated that although near-field low-frequency sounds may cause anatomical damage, research is limited, with only one study reporting mortality. The following results were summarised by Carroll *et al.* (2017):

- Acoustic source exposure caused damaged statocysts in rock lobsters up to a year post-exposure (Day *et al*., 2016). No effects were detected in snow crabs after exposure to seismic emissions (Christian *et al*., 2003);
- Studies on adult populations revealed no evidence of increased mortality due to acoustic source exposure in scallops (Parry *et al*., 2002; Harrington *et al.,* 2010), clams (La Bella *et al*., 1996), or lobsters (Payne *et al*., 2007; Day *et al*., 2016), or mortality-associated population effects such as reduced abundance or catch rates in reef-associated invertebrates (Wardle *et al*., 2001), snow crabs (Christian *et al*., 2003), shrimp (Andriguetto-Filho *et al*., 2005), or lobsters (Day *et al*., 2016);
- Dose-dependent increased mortality has been observed in transplanted scallops in suspended nets four months after exposure to an acoustic source (Day *et al.,* 2016);
- There are limited studies on the effect of seismic on metabolic rates: Payne *et al*. (2007) found no clear evidence of effects on the food consumption rate of lobsters, while Wale *et al*. (2013) showed size-dependent effects on oxygen consumption rate of crabs with only large crabs increasing oxygen consumption after exposure;
- There were no stress bioindicators (extracted from invertebrate haemolymph) in lobster (Payne *et al*., 2007), or snow crab (Christian *et al*., 2003), although increased levels of several indicators were recorded in clams immediately after exposure (La Bella *et al*., 1996). Day *et al*. (2016) provided evidence that seismic may interfere with the long-term capability of scallops to maintain homeostasis; and

- There were no adverse effects detected in the condition of scallop meat and roe quality between exposed and control sites after two different seismic surveys (Harrington *et al*., 2010).

The findings of Day *et al*. (2016) (included within the Carroll *et al*. (2017) review) challenged the previous idea of relative resilience in invertebrates to seismic exposure. Following on from the 2016 study, Day *et al*. (2019) exposed rock lobsters held in pots to acoustic source signals. Lobsters showed impaired righting and significant damage to the sensory hairs of the statocysts, with reflex impairment and damage persisting up to 365 post-exposure (Day *et al*., 2019).

The subtidal invertebrate communities expected within the Primary Operational Area and Testing Area are discussed in **Section 5.2.3** and are fairly typical of soft sandy substrates. Due to the short-term nature of the proposed Turangi 3D Seismic Survey, the highly localised area of potential effects, and the relatively small acoustic source, the overall significance of residual physiological effects on benthic invertebrates is assessed as **negligible**.

6.2.2.2.3 Cephalopods

All cephalopods have a pair of statocysts located within the cephalic cartilage (Solé *et al*., 2019) which act to regulate cephalopod behaviour such as locomotion, posture, balance, and movement in the water column (Young, 1989). Controlled exposure experiments have been undertaken on captive cephalopods to determine possible physiological effects of underwater noise. André *et al* (2011) exposed four species of cephalopod (two squid and two octopuses) to low-frequency sounds with SELs up to 175 dB re 1 $\mu Pa^2 \cdot s$. All exposed animals exhibited similar changes to the sensory hair cells of the statocysts, with damage gradually becoming more pronounced in animals continuously exposed to the noise source for up to 96 hours (André *et al*., 2011). The authors estimated that such trauma could occur out to 1.5 – 2 km from an operating acoustic source (André *et al*., 2011). Kaifu *et al.* (2007) investigated the effects of sound on the octopus *Octopus ocellatus* and showed that respiration rates were suppressed during periods of exposure to low-frequency sound.

Squid are present within the wider Taranaki region and as such could potentially occur within the Primary Operational Area and Testing Area. However, their pelagic lifestyle means that squid can readily move away from the highest sound levels close to the acoustic source and avoid physiological damage.

Inshore octopuses that could be present in the Primary Operational Area and Testing Area are typically solitary and demersal. While it is possible that octopuses could be subjected to acoustic exposure during the Turangi 3D Seismic Survey, no population level effects are anticipated.

No specific mitigation measures will be in place to reduce the potential effects of the Turangi 3D Seismic Survey on cephalopods, however, based on the small number of individuals that may be affected, the short-term nature of the proposed Turangi 3D Seismic Survey, the highly localised area of potential effects, and the relatively small acoustic source, the significance of residual physiological effects to cephalopods is considered to be **negligible.**

6.2.2.2.4 Fish

Observed physiological effects of sound on fish include increased stress levels (e.g. Santulli *et al*., 1999; Smith, 2004; Buscaino *et al*., 2010), temporary or permanent threshold shifts (e.g. Smith, 2004; Popper *et al*., 2005), and damage to sensory organs (McCauley *et al*., 2003). Fish will typically move away from a loud acoustic source if they experience discomfort (see **Section 6.2.2.3.3**), minimising their exposure and the potential for physiological effects (Vabø *et al*., 2002; Pearson *et al*., 1992; Wardle *et al*., 2001; Hassel *et al*., 2004; Boeger *et al*., 2006).

In a major literature review undertaken by scientific experts attending a Fisheries and Oceans Canada-run workshop, the following conclusions on fish physiological effects and mortality were made (DFO, 2004):

- There are no documented cases of fish mortality upon exposure to seismic sound under field operating conditions; and
- Exposure to seismic sound is considered unlikely to result in direct fish mortality.

The workshop conclusions indicated that under experimental conditions sub-lethal and/or physiological effects have sometimes been observed in fish exposed to seismic outputs; however, the experimental designs make it impossible to determine the sound intensity required to elicit the observed effects and the biological significance of the results. It was concluded that current information was inadequate to evaluate the likelihood of sub-lethal or physiological effects under field operating conditions. The ecological significance of effects could range from trivial to important, depending on their nature (DFO, 2004).

In a recent review of the effects of seismic on fish populations, Slabbekoorn *et al*. (2019) concluded that stress physiological effects are the most likely to occur in fish over injury or death, with a number of studies reporting elevated stress levels in fish subject to seismic noise. For example, Sierra-Flores *et al*. (2015) recorded increased plasma cortisol concentrations (indicating a stress response) in cod, although levels returned to baseline after approximately 20 minutes (Sierra-Flores *et al*., 2015). Similar increases in biochemical parameters followed by a drop to baseline was also observed by Santulli *et al*. (1999) in seabass, whereby elevated levels were gone after 72 hours.

Popper *et al.* (2014) developed guidelines to predict the threshold levels at which seismic surveys may cause physiological damage to fish. Using fish with a swim bladder as a worst-case scenario (i.e. the most sensitive fish hearing group), mortality and potential mortal injury may occur at levels greater than 207 dB re 1 µPa. Sound levels are predicted to exceed this level only very close to the source (<7 m, refer to **Figure 18** and **Figure 19**).

Fish located in the shallow subtidal, estuarine and river environments of the north Taranaki coastal area are unlikely to be impacted by the emitted sound waves from the proposed Waitara 3D Seismic Survey. As discussed in **Section 6.2.2.1.1**, when sound waves travel ‘up slope’ (i.e. from deep to shallow water), sound energy attenuates rapidly due to a strong interaction with the upslope seabed. This upslope interaction and attenuation can be observed in the STLM report in **Appendix A** for the modelled SELs vs range and depth plots. Modelling results have predicted that in a water depth of approximately 20 m, the SEL is ~ 110 db re 1 $\mu Pa^2 \cdot s$, well below the thresholds considered to impact fish and this continues to decrease rapidly as the sound waves travel towards the shoreline. As such, based on the strong interactions of sound energy as it travels upslope into the shallower water, noise levels are unlikely to have any impact on the nearshore or estuarine environments as the modelling predicts that the sound energy will have dissipated to very low levels.

While fish will certainly be present within the Primary Operational Area and Testing Area, they will not be present in high densities, and any fishes present are likely to be relatively mobile and able to move away from the highest SELs. Again, based on the small number of individuals that may be affected, the short-term nature of the proposed Turangi 3D Seismic Survey, the highly localised area of potential effects, and the relatively small acoustic source, the significance of residual physiological effects to fish populations from acoustic disturbance during the Turangi 3D Seismic Survey has been assessed as **negligible**.

6.2.2.2.5 Marine Reptiles

Given their rare occurrence in Taranaki waters, it is unlikely that any marine reptiles will be present in the Primary Operational Area and Testing Area during the Turangi 3D Seismic Survey. There is a paucity of literature on the potential effects of seismic surveys on marine turtles (see Nelms *et al.*, 2016), but it appears that physiological effects in marine reptiles in response to seismic surveys are rare.

It is considered that the significance of residual physiological effects on marine reptiles from acoustic disturbance during the Turangi 3D Seismic Survey will be **negligible**.

6.2.2.2.6 Seabirds and Little Blue Penguins

Seabirds and little blue penguins on the sea surface are unlikely to suffer physiological effects as noise levels at the surface are lower than those in the water column; a phenomenon known as the “Lloyd Mirror Effect” (Carey, 2009). Only birds that dive in close proximity to the acoustic source will be at risk of suffering physiological damage; to date there is no evidence of physiological effects from seismic surveys on seabirds.

Diving birds potentially present in the Primary Operational Area and Testing Area include most of the species listed in **Table 10** as foraging within the CMA, e.g. little penguin, all species of shag/cormorant, and Australasian gannet. Although these species may forage within the Primary Operational Area and Testing Area, they will likely be displaced from the immediate vicinity of the active acoustic source due to the presence of the moving survey vessel (**Section 6.2.1.2**), thus unlikely be in close enough proximity to the acoustic source to experience physiological effects.

Based on the discussion above, the significance of residual physiological effects to seabirds and little blue penguins from acoustic disturbance during the Turangi 3D Seismic Survey is considered to be **negligible**.

6.2.2.2.7 Marine Mammals

Marine mammals are highly vocal and dependent on sound for almost all aspects of their lives (Weilgart, 2007). In the event that a marine mammal is exposed to high-intensity underwater noise at close range, lethal and sub-lethal physiological effects may occur (Gordon *et al*., 2003). The sound intensities required to elicit such effects are largely unknown for most species, and current knowledge on traumatic thresholds is based on few experimental species (e.g. Southall *et al*., 2007).

The main type of auditory damage documented in marine mammals is known as a ‘threshold shift’ whereby exposed individuals exhibit an elevation in the lower limit of their auditory sensitivity; i.e. they experience hearing loss. Threshold shifts can be permanent or temporary, with temporary shifts more common in marine mammals as noise levels that elicit TTS will be experienced over much larger areas than those that elicit PTS and therefore more animals are potentially exposed. However, exposure to sounds that can cause a TTS can usually cause a PTS (i.e. permanent hearing loss) if the animal is repeatedly exposed for a sufficient period of time (Gordon *et al*., 2003). Very high SELs are believed to be required to cause immediate serious permanent physiological damage in marine mammals (Richardson *et al*., 1995). A PTS is thought to occur at 186 - 198 dB re 1 $\mu Pa^2 \cdot s$ (Southall *et al*., 2007).

The Code of Conduct sets thresholds that predict the physiological effects on marine mammals in New Zealand waters during seismic surveys, following the recommendations of Southall *et al*. (2007). The 'injury criteria' (i.e. threshold above which a PTS would be expected) is exceeded if marine mammals are subject to SELs greater than 186 dB re 1 µPa^2·s. A TTS is predicted to occur at 183 dB re 1 µPa^2·s for all cetaceans and 171 dB re 1 µPa^2·s for pinnipeds. The Code of Conduct requires mitigation measures that have been specifically designed to minimise the potential for marine mammals to be subject to SELs that could cause TTS or PTS. Compliance with the Code of Conduct mitigation measures (see **Section 3.2**) is the fundamental way in which auditory damage in marine mammals will be avoided during the Turangi 3D Seismic Survey. The protocol that the MMOs and PAM Operators will follow during the Turangi 3D Seismic Survey is detailed in the MMMP (**Appendix E**).

STLM results for the Turangi 3D Seismic Survey indicated that compliance with the 186 dB re 1 µPa^2·s threshold occurs at a maximum distance of 50 m (for the 1,000 in^3 acoustic source scenario) and that compliance with the 171 dB re 1 µPa^2·s threshold occurs at a maximum distance of 400 m (also for the 1,000 in^3 acoustic source scenario) as outlined in **Table 16**. As sound levels that could cause physiological damage would only occur within these zones, compliance with the standard Code of Conduct mitigation zones will be highly protective against physiological effects (both temporary and permanent) of marine mammals. As per the Code of Conduct requirements, the results of the STLM will be ground-truthed during the course of the Turangi 3D Seismic Survey.

In the event that a marine mammal stranding event occurs inshore of the AOI during the Turangi 3D Seismic Survey, or up to two weeks following the completion of the survey, NZSL will on a case-by-case basis consider covering the cost of a necropsy in an attempt to determine the cause of death. This will be considered following discussions with DOC. DOC would be responsible for all logistical aspects associated with the necropsy such as coordination with Massey University pathologists to undertake the work.

If exceedances of the physiological threshold for individual marine mammals do occur during the Turangi 3D Seismic Survey, a threshold shift may occur. However, threshold shifts are highly unlikely due to the typical avoidance behaviour exhibited by marine mammals, and compliance with the Code of Conduct (i.e. pre-start observations, delayed starts and shutdowns). This serves to minimise the risk to marine mammals to as low as reasonably practicable. On this basis the significance of residual physiological effects to marine mammals from acoustic disturbance during the Turangi 3D Seismic Survey is considered to be **moderate**.

6.2.2.3 Potential Behavioural Effects

A behavioural response is a demonstrable change in an animal's activity in response to a disturbance (Nowacek *et al*., 2007). Behavioural responses include movement away from an area to avoid the disturbance, or a change in normal behaviour (e.g. diving, respiration, swimming speed). The most commonly observed behavioural response is avoidance and has been widely documented in marine mammals (e.g. Stone & Tasker, 2006; Thompson *et al*., 2013; Kavanagh *et al*., 2019; Sarnocińska *et al.* 2019), seabirds (e.g. Pichegru *et al*., 2017), and fish (e.g. Engas *et al*., 1996; Slotte *et al*., 2004) during seismic operations. Some animals may be attracted to a disturbance.

Displacement from an area can lead to relocation into sub-optimal or high-risk habitats, resulting in negative consequences such as increased exposure to predators, decreased foraging or mating opportunities, alterations to migration routes, etc. Indirect effects may also occur as a result of displacement, such as disruption of a predator's feeding activities due to the displacement of prey species.

The potential for behavioural effects in each faunal grouping is discussed below.

6.2.2.3.1 Benthic Invertebrates

Exposure to seismic sound can elicit various behavioural responses in benthic invertebrates which have the potential to adversely affect a population by, for example, reducing foraging and/or predator avoidance rates, or avoidance of/movement from an area where a seismic survey has occurred. Conversely, they may elicit responses that are brief and pose no overall risk (e.g. a startle response).

Hawkins *et al*. (2015) reported that, at lower sound levels, behavioural responses are more likely to occur than physical and/or physiological responses. Behavioural responses are the most difficult to monitor *in situ* and consequently, many studies investigating the behavioural effects of seismic operations on benthic invertebrates are conducted under laboratory conditions or by deploying caged individuals in the field (Carroll *et al*., 2017).

Cote *et al*. (2020) used a before-after-control-impact approach to investigate the potential for seismic surveys to modify movement behaviour of free-ranging snow crab. Within each study area (test and control area), movements of tagged snow crabs were tracked using acoustic positioning and acoustic receivers before, during and after exposure to a 2D seismic survey. Cote *et al.* (2020) reported that the magnitude of behavioural effects were at most small or were not statistically relevant, most likely due to the high level of natural variation in snow crab movements in response to environmental variables (e.g. diel cycles, water temperature and tide).

Christian *et al*. (2003) also examined snow crab behaviour before, during and after seismic exposure. While in the laboratory the crabs reacted slightly when sharp sounds were made near them, caged crabs in the field showed no readily visible reactions to the acoustic source operating 50 m above them. As with Cote *et al*. (2020), Christian *et al*. (2003) did not observe any large-scale movements out of the area.

Day *et al.* (2016) conducted a field experiment in Tasmanian waters to assess the behavioural responses of rock lobsters (*Jasus. edwardsii*) to a 150 in^3 acoustic source. This study found that seismic exposure significantly increased righting time of lobsters that had been placed on their backs. The ecological result of this could potentially increase the predation rates of exposed individuals.

Day *et al*. (2016) also investigated the behavioural effects of seismic on scallops and report that scallops exposed to seismic display a distinctive flinching response, an increase in burial rate and are slower at righting themselves than control scallops. No energetically costly responses, such as swimming, have been observed in scallops due to exposure to an acoustic source.

Benthic invertebrates within the Primary Operational Area and Testing Area will include various amphipods, polychaetes, decapods, and bivalves (**Section 5.2.3**). These communities will likely be wide-spread throughout the wider North Taranaki region, and any effects will not result in population-wide impacts. The significance of residual behavioural effects to benthic invertebrates from acoustic disturbance during the Turangi 3D Seismic Survey has therefore been assessed as **negligible**.

6.2.2.3.2 Cephalopods

Behavioural changes in response to acoustic disturbance have been documented for cephalopods. Caged cephalopods exposed to acoustic sources demonstrated a startle response above 151 – 161 dB re 1 µPa and tended to avoid the acoustic disturbance by exhibiting surface behaviours (McCauley *et al*., 2000). The authors suggested that thresholds affecting squid behaviour occur at 161 – 166 dB re 1 µPa RMS and that the use of soft-starts effectively decrease the startle response.

Fewtrell (2003) investigated the response of southern calamari squid to seismic emissions and found avoidance behaviours once the noise levels exceeded 158 dB re 1 µPa, with significant increases in alarm responses with noise exceeding 158 – 163 dB re 1 µPa. There was a decrease in the frequency of alarm responses from repeated exposures, suggesting that the animals are becoming habituated (Fewtrell, 2003).

Fewtrell and McCauley (2012) further demonstrated that a source level of 147 dB re 1 µPa was necessary to induce an avoidance reaction in squid. Fewtrell and McCauley (2012) observed other reactions, including alarm responses (such as inking and jetting away from the source), increased swimming speed and aggressive behaviour. The authors found that there was an increase in the alarm response from the squid as the acoustic release noise levels increased beyond 147 – 151 dB re 1 µPa SEL. The reaction of the animals decreased with repeated exposure to the acoustic source suggesting either habituation or impaired hearing (Fewtrell & McCauley, 2012).

There is the potential for squid and octopuses to come near the acoustic source during the Turangi 3D Seismic Survey and noise levels that could elicit a behaviour response could be experienced by individuals in the vicinity of the survey vessel; however any effect will disappear rapidly after the cessation of operations. On this basis, the significance of residual behavioural effects to cephalopods from acoustic disturbance during the Turangi 3D Seismic Survey has been assessed as **minor**.

6.2.2.3.3 Fish and Commercial Fisheries

The presence or absence of a swim bladder in fish is a major factor in determining the response of fish to acoustic disturbances. Species with swim bladders or other gas-filled chambers are generally more sensitive to sound and more likely to suffer adverse effects.

Studies into the behavioural impacts of seismic on fish are typically experimental, whereby caged fish are exposed to an acoustic source or involve assessments of fisheries catch-effort data before and after a seismic survey. Variability in experimental design (e.g. source level, line spacing, timeframe, geographical area, etc.) and test subject (e.g. species, wild vs. farmed, demersal or pelagic, migratory or site-attached, etc.) often makes overall conclusions and comparisons difficult, while may studies are also limited in biological relevance or lack sufficient replication or controls (Slabbekoorn *et al*., 2019). Captive studies typically only provide information on the behavioural responses of fish during and immediately after the onset of noise (Popper & Hastings, 2009), and laboratory experiments often apply intensities or durations of sound exposures that are unlikely to be encountered in the wild (Gray *et al*., 2016). Caged studies are potentially biased as subjects are constrained and may be unable to exhibit avoidance behaviours that would be possible in the wild.

In general, there is little evidence of long-term behavioural disruption in fish. Slotte *et al*. (2004) provided the only evidence of a long-term behavioural effect of fish in response to a commercial 3D seismic survey off the coast of Norway. Acoustic mapping was used to investigate the abundance of herring and blue whiting within and outside (up to 30 – 50 km) the seismic area. Acoustic abundance was consistently higher outside the seismic area than inside, with this interpreted to be in indication of long-term displacement.

In contrast, short-term responses are relatively common, and include startle responses (Pearson *et al*., 1992; Wardle *et al*., 2001; Hassel *et al*., 2004; Boeger *et al*., 2006), modification in schooling patterns and swimming speeds (Pearson *et al*., 1992; McCauley *et al*., 2000; Fewtrell & McCauley, 2012), freezing (Sverdrup *et al*., 1994), and changes in vertical distribution within the water column (Pearson *et al.,* 1992; Fewtrell & McCauley, 2012). Although studies to date do not yield completely coherent results, they suggest that fish may stop foraging and start swimming down the water column (Slabbekoorn *et al*., 2019).

Short-term displacement has been documented during seismic surveys through observed vertical and horizontal avoidance away from the active seismic source (e.g. Pearson *et al*., 1992; McCauley *et al*., 2000; Colman *et al*., 2008; Handegard *et al*., 2013), while some studies have failed to detect any changes (e.g. Wardle *et al*., 2001; Peña *et al.,* 2013). Hassel *et al.* (2004) found evidence of habituation to underwater noise through time based on a decrease in the degree of startle response.

A concern around changes to fish behaviours is the potential for flow-on effects on commercial fisheries (McCauley *et al*., 2000). Slabbekoorn *et al.* (2019) suggested that the impact on catch rates can be positive or negative depending on the type of fisheries; catch rates can go up for gill nets which depend on swimming activity or can go down for longlines which depend on active foraging. Studies into the effects of seismic on catch rates have revealed contradictory results, with some studies demonstrating a reduction in catch per unit effort (e.g. Skalski *et al*., 1992; Engas *et al*., 1996; Bendell, 2011; Handegard *et al*., 2013), while no observable change was documented by others (e.g. Pickett *et al*., 1994; Labella *et al*., 1996; Jakupsstovu *et al*., 2001). Observed effects were typically short-term, with no evidence of long-term displacement. Jakupsstovu *et al*. (2001) noted that although many fishers perceived a decrease in catch during seismic operations, logbook analysis revealed no statistically significant effects. Gausland (2003) has debated reported reductions in catch per unit effort, attributing changes instead to natural fluctuations in fish stocks or long-term negative trends.

Bruce *et al*. (2018) conducted a field-based study to assess behavioural effects in three species (gummy shark, swell shark, tiger flathead), and a desktop study to assess any changes in commercial fish catch in response to a 2D seismic survey in the Gippsland Basin, Bass Strait, Australia. While the range of responses observed were species-specific, the following conclusions were made (Bruce *et al*., 2018):

- Behaviour consistent with a possible response to the survey was observed for flathead, with an increase in swimming speed during the survey and change in diel movement patterns after the survey;
- Of the 15 species examined for changes in catch rates, six increased in catch following the survey, and three showed reductions in catch rate; and
- Overall, with the exception of flathead movement, there was little evidence for consistent behavioural or catch rate changes induced by the seismic survey in the target species.

Meeken *et al* (2021) investigated the effects of 3D seismic surveys on the Pilbara Trawl Fishery off Western Australia. Exposure to two 2,600 in^3 airgun arrays was assessed over 5 days where ‘high exposure’ and ‘inactive’ sail lines were used to create two sampling zones (impact and control) separated by 36 km. The effective source level of the airgun array was 231 dB re 1 µPa @ 1 m (mean square pressure) and baited underwater videos were used to assess fish behaviour at both impact and control sites. The authors concluded that exposure to seismic noise caused no discernible short- or long- term effects on the composition, abundance size structure behaviour or movement of tropical demersal fishes targeted by this fishery.

The level of commercial fishing within the Primary Operational Area and Testing Area is likely to be relatively low on account of the coastal nature of the area and fishing restrictions in place under the Fisheries Act 1996. Based on the low level of commercial fishing in the Primary Operational Area and Testing Area, the lack of evidence of long-term effects on fish stocks, the short duration of behavioural effects, and restricted spatial extent of any effects, the significance of residual behavioural effects on fish and flow-on effects on commercial fishery catch rates has been assessed as **minor**.

6.2.2.3.4 Marine Reptiles

There is no information available on the effects of seismic surveys on sea snakes, although a recent study by Chapuis *et al* (2019) has demonstrated that sea snakes are sensitive to low-frequency sounds, although have a low sensitivity compared to marine turtles.

Patterns of avoidance and behavioural changes have been observed in sea turtles. Captive sea turtles (i.e. loggerhead and green turtles) exposed to an approaching acoustic source displayed a behavioural response of an increase in swimming speed and an avoidance response of erratic swimming (McCauley *et al*., 2000). Avoidance behaviours in loggerhead turtles were also documented by De Ruiter and Doukara (2012) with dive probability decreasing with increasing distance to the acoustic source. De Ruiter and Doukara (2012) interpreted this dive response as behavioural avoidance response.

As the Primary Operational Area and Testing Area are not of particular importance to marine reptiles (e.g. does not support nesting sites) and the occurrence of marine reptiles is highly unlikely, the significance of residual behavioural effects to marine reptiles from acoustic disturbance during the Turangi 3D seismic Survey is **negligible.**

6.2.2.3.5 Seabirds and Little Blue Penguins

Despite there being little information on the behavioural effects of seismic on seabirds, the possibility of disruption to feeding activities has been identified. Seabird and little blue penguin feeding behaviours could be interrupted by acoustic disturbance from a seismic vessel passing through feeding grounds (Goudie & Ankey, 1986), or birds could become alarmed as seismic operations pass close-by, causing them to temporarily stop diving (MacDuff-Duncan & Davies (1995). In addition to the potential direct displacement of seabirds and little blue penguins, the displacement of bait fish may lead to a reduction in diving activities and foraging potential in the immediate vicinity of seismic operations (see **Section 6.2.2.5)**.

Lacroix *et al*. (2003) assessed the effect of seismic on the foraging behaviour of moulting male long-tailed ducks in the Beaufort Sea. Their findings indicated that the abundance and distribution of ducks in seismic and control areas changed similarly following the start of seismic operations suggesting that other influencing factors (e.g. wind) were more important for duck distribution, and that seismic activity did not significantly change the diving intensity of ducks (Lacroix *et al*., 2003). Overall, Lacroix *et al*. (2003) concluded that there was no evidence to suggest any displacement away from active seismic operations.

Pichegru *et al*. (2017) assessed the foraging behaviour of African penguins before, during and after a marine seismic survey operating within 100 km of penguin breeding colonies. Penguins foraging within 100 km of the active seismic source showed a change in foraging direction, increasing the distance between feeding area and the seismic vessel. Displaced penguins reverted to normal foraging behaviours following the cessation of seismic activities, suggesting effects are relatively short-lived (Pichegru *et al.,* 2017). The authors were unable to differentiate between penguins shifting foraging activities in direct response to the survey (i.e. behavioural effect) or indirectly due to a change in prey distribution; however, a behavioural response was determined as the most likely cause (Pichegru *et al.,* 2017).

The results of Lacroix *et al.* (2003) and Pichegru *et al.* (2017) suggest that, at most, seabirds and little blue penguins will be temporarily displaced from areas of active seismic operations. Such displacement effects are anticipated to be short-lived, with animals able to return to traditional feeding grounds following the cessation of seismic activities. Foraging of little blue penguins could be affected by the Turangi 3D Seismic Survey, but the short-term duration of the survey will minimise disturbance to seabird behaviour and consequently the significance of residual behavioural effects to seabirds and little blue penguins from acoustic disturbance is assessed as **minor**.

6.2.2.3.6 Marine Mammals

Avoidance of seismic operations by marine mammals has been well documented in scientific literature (e.g. Stone & Tasker, 2006; Thompson *et al*., 2013; Kavanagh *et al*., 2019; Sarnocińska *et al.* 2019). Although behavioural responses may not have direct lethal effects, there is potential for sub-lethal effects such as increases in energy expenditure and demand, decreased foraging efficiency, disruption of group dynamics (e.g. group cohesion), and lowered reproductive rates leading to population-wide effects (Weilgart, 2007;2013). Behavioural effects may also be harmless (Weilgart, 2007).

Several factors determine the response of marine mammals to acoustic disturbance, such as species, individual, age, sex, behavioural state, and any prior experience with noise (Weilgart, 2007). Most studies have typically focused on opportunistic observations of surface behaviours (Verfuss *et al*., 2018); although behavioural responses may be subtle and barely detectable and may potentially be interpreted as an apparent tolerance of the studied animal(s) (Weilgart, 2007).

Increased surface behaviours such as breaching or increases in time spent at the surface has been interpreted as a way of reducing exposure to high sound levels on account of the ‘Lloyd mirror effect’, whereby the sound intensity within the upper-most part of the water column is significantly reduced (Carey, 2009). For example, more cetaceans (humpback whales, sperm whales, and Atlantic spotted dolphins) were seen during acoustic source activity than when the acoustic source were silent, indicating that the whales remained at the surface at times of high noise (Weir, 2008). Other stress-related behaviours that have been documented in the vicinity of operating seismic surveys include changes in respiration rate (Richardson *et al*., 1995), swimming speed (Stone & Tasker, 2006), and alterations to diving behaviour (Richardson *et al*., 1995).

Marine mammal distribution is typically linked to that of their prey (Fielder *et al*., 1998), and any avoidance response could lead to abandonment of valuable feeding grounds (e.g. large aggregations of krill) or reduced foraging effort. It is noteworthy that the Primary Operational Area is not a known hotspot for marine mammal foraging.

There is anecdotal evidence of attraction of marine mammals to seismic operations. McCauley *et al*. (2000) observed what are believed to be male humpback whales approaching an operating acoustic source and hypothesised that this was due to the similarity to sound produced by breaching whales. New Zealand fur seals are also known to approach operating seismic vessels (Lalas & McConnell, 2016).

Compliance with the Code of Conduct requirements for a Level 1 survey will be the primary mitigation measure employed during the Turangi 3D Seismic Survey to manage behavioural effects on marine mammals. In accordance with the Code of Conduct qualified MMOs and PAM Operators will be present on the survey vessel and will maintain watch (including pre-start observations) for marine mammals and will implement the mandatory management actions when required (e.g. delayed starts and shut-downs). While shutdowns and delayed starts are designed to protect marine mammals primarily from physiological effects, delayed starts also serve to reduce behavioural effects in that marine mammals that may be present are supported to continue whatever behaviour they may be engaged in without disturbance from seismic operations.

Specifications of the PAM system proposed for the Turangi 3D Seismic Survey will be assessed by DOC to ensure that the system meets the PAM standards described in the Code of Conduct. Full technical specifications of the PAM system are provided in **Appendix B.**

NZSL will also employ the following mitigation measures:

- Acquisition of acoustic data will only occur during daylight hours;
- Two MMOs and at least one PAM Operator will be on duty at all times when the acoustic source is in the water; and
- The first source activation of each survey day will be treated as a ‘new location’ with additional pre-start observation requirements in poor sighting conditions.

In addition, DOC Taranaki will be notified in advance of the days when the source is likely to be active, and MMOs and PAM Operators onboard the survey vessel will immediately notify DOC of any Hector’s/Māui’s dolphin sightings. The full protocol that the MMOs and PAM Operators will be following during the Turangi 3D Seismic Survey is detailed in the MMMP. The MMMP is provided in **Appendix E**.

In line with the discussions above, it is acknowledged that behavioural changes are possible for marine mammals during the Turangi 3D Seismic Survey, but the small number of individuals that may be affected, the short-term nature of the proposed survey, and the relatively small acoustic source; no long-term behavioural effects or displacement of marine mammals are predicted. The significance of residual behavioural effects on marine mammals from the Turangi 3D Seismic Survey is therefore considered to be **moderate**.

6.2.2.4 Potential Perceptual Effects

Many marine species produce sound for a variety of functions including navigation, communication, and predator and prey detection, and even those that do not produce sound will utilise the surrounding soundscape to gain overall awareness of the environment (Fay & Popper, 2000). The addition of noise into the marine environment can disrupt and animal’s communication potential and/or ability to detect biologically important signals (Dunlop *et al*., 2010); this is referred to as ‘masking’. Masking is an increase in the threshold for detection or discrimination of one sound as a consequence of another (Brumm & Slabbekoorn, 2005), and can be either complete (i.e. signal is not detected at all) or partial (i.e. signal is detected by unable to be properly understood) (Clark *et al*., 2009).

Examples of effects of masking on an animal’s fitness and survival include:

- Blocking or alteration of signals alerting to the presence of predators (Lowry *et al*., 2012);
- Incorrect assessment of the quality of rivals or potential mates lowering reproductive success (Halfwerk *et al*., 2011);
- Disruption in the ability to locate prey/food and decrease in foraging efficiency (e.g. Clark *et al.,* 2009; Siemers & Schaub, 2010); and
- Disruption in group cohesion through a breakdown in communication particularly between parents and offspring (Leonard & Horn, 2012).

The following provides a discussion on the effects of masking on auditory communication of fish and marine mammals.

6.2.2.4.1 Fish

Many fish species produce sounds for communication, with vocalisations typically within a frequency band of 100 Hz to 1 kHz (Ladich *et al*., 2006; Bass & Ladich, 2008). While there have been no studies into the masking of fish communications by seismic surveys, other anthropogenic sounds such as boat noise have reportedly caused masking (e.g. Picciulin *et al*., 2012), therefore, it is reasonable to assume that sound emissions from a seismic survey could result in the masking of fish calls. Popper *et al*. (2014) suggested that for fish with good hearing, there is a greater likelihood of masking further from the acoustic source than close to it as masking is more likely for these fish when the animals are far enough away from the source for the sounds to merge and become more or less continuous.

Radford *et al*. (2014) suggested that fish might adapt to masking in the following ways:

- Spatial or temporal avoidance of noise. Temporal avoidance involves taking advantage of gaps or fluctuations in competing noise, for example Luczkovich *et al.* (2000) reported that silver perch vocalised less frequently when recordings of a predator (i.e. bottlenose dolphin) were played;
- Temporal adjustments. Signal detection enhances as signal duration increases as a consequence of an increase in the probability that some of the signal is detected during a quieter period. Fine and Thorsen (2008) recorded an increase in toadfish call rate to compete acoustically in the presence of rival males;
- Frequency shifts. Broadband sounds are more difficult to detect in a noisy environment than pure tones, for example freshwater gobies in waterfall habitats produce vocalisations in a frequency different from that of the waterfall noise. The gobies utilise available ‘windows’ in the background frequency range (Lugli *et al*., 2003);
- Amplitude shifts. In a noisy environment, an increase in amplitude increases signal detection (i.e. the Lombard Effect). While the Lombard Effect has been demonstrated in several vertebrates, it is yet to be demonstrated in fish in response to anthropogenic noise; and
- Change in signalling modality. The repertoire of a species usually consists of more than one signal component; hence when one signal type is ineffective, the caller may swap to another signal type to increase the chance of detection, e.g. a change from vocalisations to visual signals.

Although little is known on the vocalisations of fish throughout the Taranaki region, it is reasonable to assume that the Turangi 3D Seismic Survey may lead to masking for some fish species. However, based on the mobile nature and likely low abundances of the fish potentially present in the Primary Operational Area and Testing Area, no biologically significant effects are expected and the significance of residual perceptual effects on fish is considered to be **minor**.

6.2.2.4.2 Marine Mammals

Marine mammals use sounds to gain an overall awareness of the surrounding environment, and to inform a variety of behaviours including foraging, navigation, communication, reproduction, parental care, and predator avoidance (Thomas *et al*., 1992; Johnson *et al*., 2009), therefore the ability to perceive biologically important sounds is crucial to marine mammals.

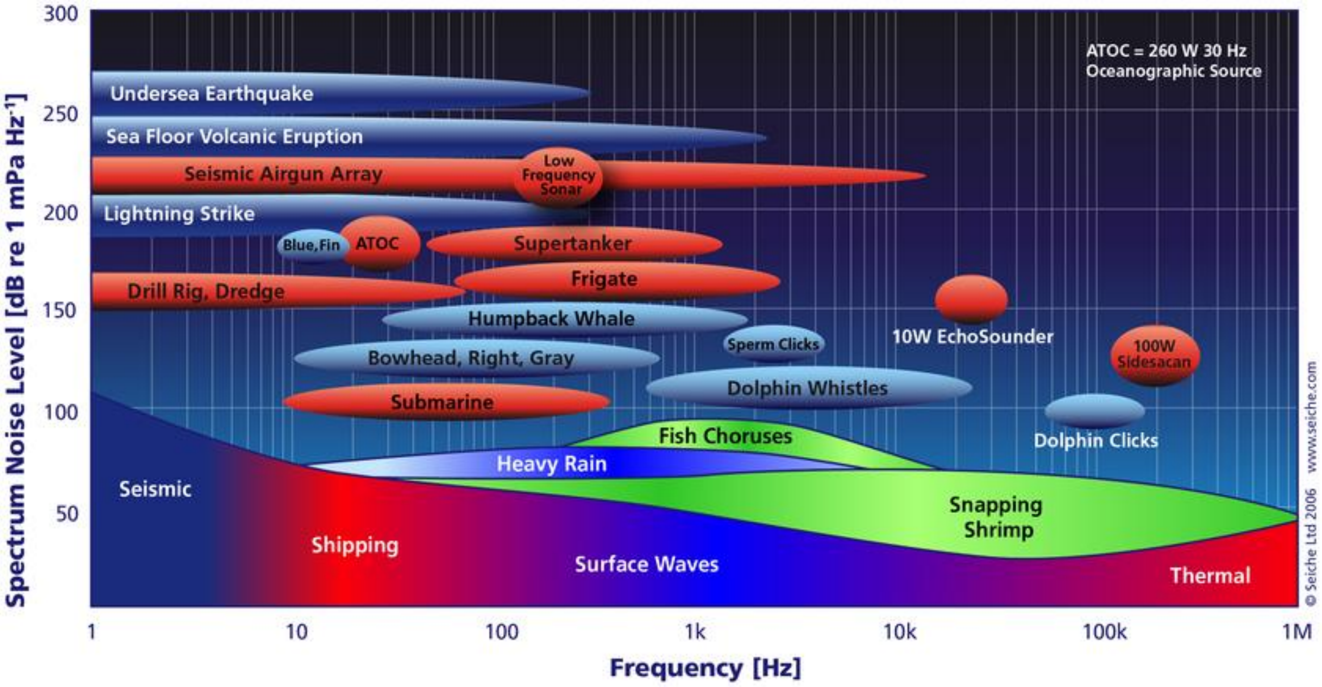
Masking is a common effect of acoustic disturbance on marine mammals and occurs when the ability to detect or recognise a sound of interest is degraded by the presence of another sound (the masker) (Erbe *et al*., 2016). The level of masking that would occur depends on a number of factors other than the noise doing the masking, such as the location of the sender and receiver, source level and spectral characteristics of the signal, and the receiving animal’s auditory capabilities (Erbe *et al*., 2016).

Cetaceans are broadly separated into three categories based on hearing capability (Southall *et al*., 2007):

- Low frequency cetaceans: have an auditory bandwidth between 0.007 kHz and 22 kHz. Species from this group that could occur in the Primary Operational Area include southern right whale, humpback whale, pygmy right whale, Bryde's whale, and fin whale;
- Mid-frequency cetaceans: with an auditory bandwidth between 0.15 kHz and 160 kHz. Species from this group that could occur in the Primary Operational Area include common dolphin, dusky dolphin, killer whale, pilot whales, sperm whale, and beaked whales; and
- High frequency cetaceans: which an auditory bandwidth between 0.2 kHz and 180 kHz. Species from this group that could occur in the Primary Operational Area include pygmy sperm whales, and Hector's and Māui dolphins.

Sound frequencies emitted by seismic acoustic sources are broadband, but with most of the energy concentrated between 0.1 kHz and 0.25 kHz. The greatest potential for interferences with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum i.e. the lowest frequency cetaceans are particularly affected since they have the most overlap with the frequencies of the seismic survey acoustic sources (**Figure 22**). Auditory masking of mid and high frequency cetacean vocalisations is less likely as these species generally operate at higher frequencies than those generated by a seismic survey.

Figure 22 Ambient and localised noise sources in the ocean



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

Erbe *et al*. (2016) documented several studies demonstrating adaptive responses/anti-masking strategies in cetaceans reacting to underwater anthropogenic noise, including changes in vocalisation strength, frequency, and timing. Adaptations have been documented in blue whales (Di lorio & Clark, 2009), humpback whales (Dunlop *et al*., 2014), beluga whales (Lesage *et al*., 1999), right whales (Parks *et al*., 2007, 2011), killer whales (Holt *et al.*, 2008), common dolphins (Ansmann *et al.,* 2007) and bottlenose dolphins (van Ginkel *et al*., 2017). It is thought that an increase in calling leads to an increase in the probability that signals will be successfully received by conspecifics due to a reduction in the effects of auditory masking.

Cetaceans may also cease vocalising in response to anthropogenic noise. For example, singing activity of humpback whales at breeding grounds off Angola declined in the presence of a seismic survey and increasing received levels of the seismic pulses (Cerchio *et al*., 2014). Due to this cessation in singing occurred at a breeding ground, the authors suggested there may be resulting effects on mating behaviour and success (Cerchio *et al*., 2014). Clicking also ceased in sperm whales in response to weak seismic survey pulses (received level of 115 dB re 1 µPa) (Bowles *et al*., 1994); although contradictory to Bowles *et al*. (1994), Madsen *et al*. (2002) did not document any changes in sperm whale clicks in response to a seismic survey off Norway.

Adaptations to masking for some species may be limited to circumstances when whales are subject to low to moderate SELs. For example, Blackwell *et al*. (2015) demonstrated that the calling rates of bowhead whales varied with changes in received SEL. As SELs increased, calling rates levelled off (as SELs reached 94 dB re 1 µPa^2·s), then began decreasing (at SELs greater than 127 dB re 1 µPa^2·s), with whales falling virtually silent once SELs exceeded 160 dB re 1 µPa^2·s.

There are no auditory thresholds for masking effects on cetaceans (Erbe *et al*.,2016); however, masking responses have been documented to occur at relatively low exposure levels (i.e. lower than what would elicit a behavioural response). It is likely that cetaceans in the vicinity of the Primary Operational Area and Testing Area may be subject to some masking effects; however, any masking will cease at the completion of the Turangi 3D Seismic Survey, and it is highly unlikely that any masking will have detectable population effects on cetaceans within the Taranaki region.

In addition to this, Māui's dolphins, which are of particular interest to this survey given the survey's overlap with the North Island West Coast Marine Mammal Sanctuary, are classified as 'high frequency cetaceans' meaning that their auditory bandwidth occurs between 0.2 kHz and 180 kHz. In contrast, frequencies emitted by seismic sources are broadband, with most of the energy concentrated between 0.1 kHz and 0.25 kHz. Hence there is only a very small overlap between the two frequency ranges meaning that much of the underwater noise generated by seismic surveys is likely to be inaudible to Māui's dolphins and therefore masking for this species is unlikely. As NZSL will only acquire seismic data during daylight hours, the hours of darkness will remain unaffected by seismic operations therefore masking will not occur on a continual basis over the survey duration. Overall, the significance of residual perceptual effects on cetaceans has been assessed as **moderate**.

6.2.2.5 Potential Indirect Effects

In addition to physiological, behavioural, and perceptual effects from underwater noise, there is also the potential for marine fauna (i.e. marine mammals, seabirds and predatory fish) to be affected through indirect effects of noise exposure. Indirect effects include changes to the distribution and abundance of prey species (Simmonds *et al*., 2004), decreased foraging efficiency, higher energetic demands, lower group cohesion, higher predation rates and decreased reproduction rates (Weilgart, 2007). Indirect effects are difficult to detect and measure and may or may not be detrimental depending on the specific circumstances of exposure.

The most significant and immediate potential indirect effects of noise on marine fauna is considered to be the change in prey (zooplankton and fish) distribution and abundance (see **Sections 6.2.2.2.1**, **6.2.2.2.4**, and **6.2.2.3.3**). These potential effects can in turn lead to a decrease in foraging efficiency of marine predators, such as marine mammals, which can in turn potentially lead to compromised growth, body condition, reproduction and ultimately survival.

Although there is some potential for indirect effects on marine mammals, seabirds and predatory fish from the Turangi 3D Seismic Survey, there is a general lack of scientific information about such effects. On account of the difficulty to predict with any certainty what indirect effects might occur, the ability to target management measures to avoid, remedy or mitigate indirect effects is also difficult. However, the relatively short timeframe associated with the Turangi 3D Seismic Survey (approximately seven days of acquisition and 21 days for the full survey from node receiver deployment to retrieval) and relative low abundance of marine fauna expected within the Primary Operational Area and Testing Area will minimise any potential indirect effects. Based on this, the significance of residual indirect effects from the Turangi 3D Seismic Survey is assessed as **minor**.

6.2.3 Waste Discharges and Emissions

The survey vessel will produce wastes during the Turangi 3D Seismic Survey as biodegradable and non-biodegradable wastes, and atmospheric emissions from exhausts.

Inappropriate discharges of these wastes have the potential to cause adverse effects on the surrounding environment; however, given the short duration of the survey and low number of personnel onboard the survey vessel, the volume produced during the survey is likely to be minimal.

All produced wastes will be managed in accordance with NZSL environmental practices, and relevant legislation.

6.2.3.1 Potential Effects from Biodegradable Waste

Biodegradable wastes likely to be produced on survey vessel during the Turangi 3D Seismic Survey include:

- Black water (sewage/faecal wastewater from toilets);
- Grey water (wastewater from sinks);
- Galley wastes; and,
- Oily water (from bilges).

Waste discharges naturally undergo bacterial decomposition either within the water column or upon reaching the seabed, resulting in two consequences for the surrounding environment (Perić, 2016; Wilewska-Bien *et al*., 2016); decreased oxygen concentrations as a result of increased biological oxygen demand by bacteria decomposing the discharged wastes, and increased nitrogen and phosphorous released from decomposed materials. In areas of low flow or restricted mixing oxygen can become low enough to be biologically limiting for marine organisms. Increased nitrogen and phosphorous concentrations can also stimulate the growth of algae (phytoplankton) including potentially toxic species or cause further increased oxygen demand as a bloom crashes and dying plankton begin to decay. Untreated sewage and grey water can contain human pathogens such as Salmonella and gastro-intestinal viruses (Perić, 2016; Wilewska-Bien *et al*., 2016).

While discharges (i.e. bilge water, sewage, and ballast water) from shipping and boating regularly occur into the CMA, their impacts on water quality and seafood is regarded as slight, with the exception of within New Plymouth harbour (Patrick, 2000).

Under the Resource Management (Marine Pollution) Regulations 1998, the discharge of untreated sewage into the marine environment must not occur within 500 m from land (mean high water spring), or in water less than 5 m deep.

The following will be followed throughout the duration of the Turangi 3D Seismic Survey to mitigate against adverse effects from the discharge of biodegradable wastes:

- All sewage and grey water will be collected onboard the survey vessel for discharge at an approved land-based facility;
- Biodegradable wastes will be collected for disposal at an approved land-based facility; and
- Discharges containing oils will pass through onboard treatment systems and will only be discharged when below oil-in-water concentrations of 15 ppm.

The significance of residual effects to the marine environment from routine discharges of biodegradable waste generated by the survey vessel are considered to be **negligible.**

6.2.3.2 Potential Effects from Non-biodegradable Waste

Non-biodegradable wastes/garbage (e.g. plastics used in food wrapping and packaging) entering the marine environment can have severe detrimental and even lethal effects on marine fauna, while contributing to a global pollution problem. Smaller pieces of such wastes are often ingested by animals (including seabirds, fish, turtles, and marine mammals) and can accumulate in the gut leading to internal injury, blockage of intestinal tracts, and a reduction in fitness (Derraik, 2002). Larger objects may cause entanglement, injury, disfigurement or even death for certain animal species that become caught by, or interact with, these wastes. By their nature non-biodegradable wastes often persist in the marine environment for extensive periods of time and can accumulate on the surface or on the seabed or may be transported large distances from the original discharge point (Li *et al*., 2016).

All non-biodegradable wastes will be stored onboard the survey vessel where they will be returned to shore for disposal in adherence to local waste management requirements.

The significance of residual environmental risk from any non-biodegradable discharges to the marine environment during the Turangi 3D Seismic Survey is considered to be **negligible**.

6.2.3.3 Potential Effects from Atmospheric Emissions

Exhaust gasses produced by internal combustion engines (e.g. main engines, generators, deck equipment) present on the survey vessel will be the primary sources of atmospheric emissions during the Turangi 3D Seismic Survey. Exhaust emissions will be primarily composed of carbon dioxide and carbon monoxide but will also include small quantities of other toxic inorganic gasses such as nitric oxide and nitrogen dioxide (Steiner *et al*., 2016).

While exhaust gasses can reduce the ambient air quality, the low level of emissions will be comparable to those from other vessels that routinely transit the CMA. As a result, the significance of any residual atmospheric emissions during the Turangi 3D Seismic Survey is considered to be **negligible**.

6.2.4 Cumulative Effects

Cumulative effects can occur where multiple sound sources combine leading to an overall increase in underwater sound levels. Of 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 above its natural baseline level. Assessing cumulative effects in a quantitative manner is challenging and few studies have broached this topic in relation to seismic surveys.

Of particular concern is the potential for cumulative noise effects arising from multiple seismic surveys overlapping temporally (i.e. at the same time) or spatially (i.e. over the same area but not necessarily over the same time period). Except for the Turangi 3D Seismic Survey, there are no known planned seismic surveys in the North Taranaki CMA in the next 12 – 24-month period, and few surveys have occurred in the West Coast North Island Marine Mammal Sanctuary in recent years therefore cumulative effects from multiple seismic surveys are not considered further.

The other main anthropogenic sound source that could contribute to cumulative acoustic effects during the Turangi 3D Seismic Survey is shipping. Although the Primary Operational Area does not lie within a main shipping route, underwater noise from ships visiting Port Taranaki will be audible to cetaceans in the AOI as will smaller fishing vessels and recreational vessels that operate off the north Taranaki coast.

In some circumstances underwater noise from seismic sources are intense and can over-ride other inputs of underwater noise. For instance, Di lorio and Clark (2009) assessed the calling rate of blue whales during a seismic survey and concluded that shipping noise in the operational area did not account for any of the observed changes in the acoustic behaviour of blue whales, but that the seismic survey was solely responsible for these changes. However, where shipping levels are relatively low (such as within the Primary Operational Area), the combined noise levels from seismic surveys and shipping could result in greater disturbance to marine mammals compared with either activity alone (Di lorio & Clark, 2009). McGregor *et al*. (2013) showed that marine mammals sometimes adapted their vocalisations in order to mitigate against the effects of masking in areas of consistent underwater noise, supporting the generally held notion that masking effects of underwater noise are most significant in areas where baseline noise levels are typically low. Coastal and offshore Taranaki waters are used by ships in transit, as well as those involved in fishing activities and hence shipping noise is considered an existing feature in Taranaki waters; however, the addition of noise from the Turangi 3D Seismic Survey is unlikely to contribute significantly to masking of resident marine mammals on account of the short-duration of the survey and the small acoustic source that will be utilised.

As mentioned earlier, auditory bandwidth for Māui’s dolphins occurs between 0.2 kHz and 180 kHz. In contrast, frequencies emitted by seismic sources are broadband, with most of the energy concentrated between 0.1 kHz and 0.25 kHz. Hence there is only a very small overlap between the two frequency ranges meaning that much of the underwater noise generated by seismic surveys is likely to be inaudible to Māui’s dolphins. The nominal range of underwater noise from large commercial ships is 0.01 – 10 kHz (Tasker *et al*., 2010 as cited by Merchant *et al*., 2014); and while the overlap between the auditory bandwidth for Māui’s dolphins and shipping is greater than that for seismic surveys, the overlap is not particularly extensive. On this basis, the higher frequency outputs of smaller inshore fishing vessels and recreational vessels on an ongoing basis are likely to be of great significance to Māui’s dolphins than either seismic surveys or commercial shipping.

When assessing the potential cumulative effects on a small inshore threatened cetacean (e.g. Māui’s dolphin) it is important to consider the other threats that Māui’s dolphins face throughout their range. Anthropogenic threats to this species were recently summarised by Roberts *et al*. (2019) as commercial set net and inshore trawl fisheries, toxoplasmosis, recreational fishing, aquaculture, oil spill risk, seismic survey and vessel noise; where commercial fishing and toxoplasmosis were highlighted as key threats whist noting that other ‘probable key threats’ included climate change and that the cumulative effects of multiple threats may also pose substantial population risk.

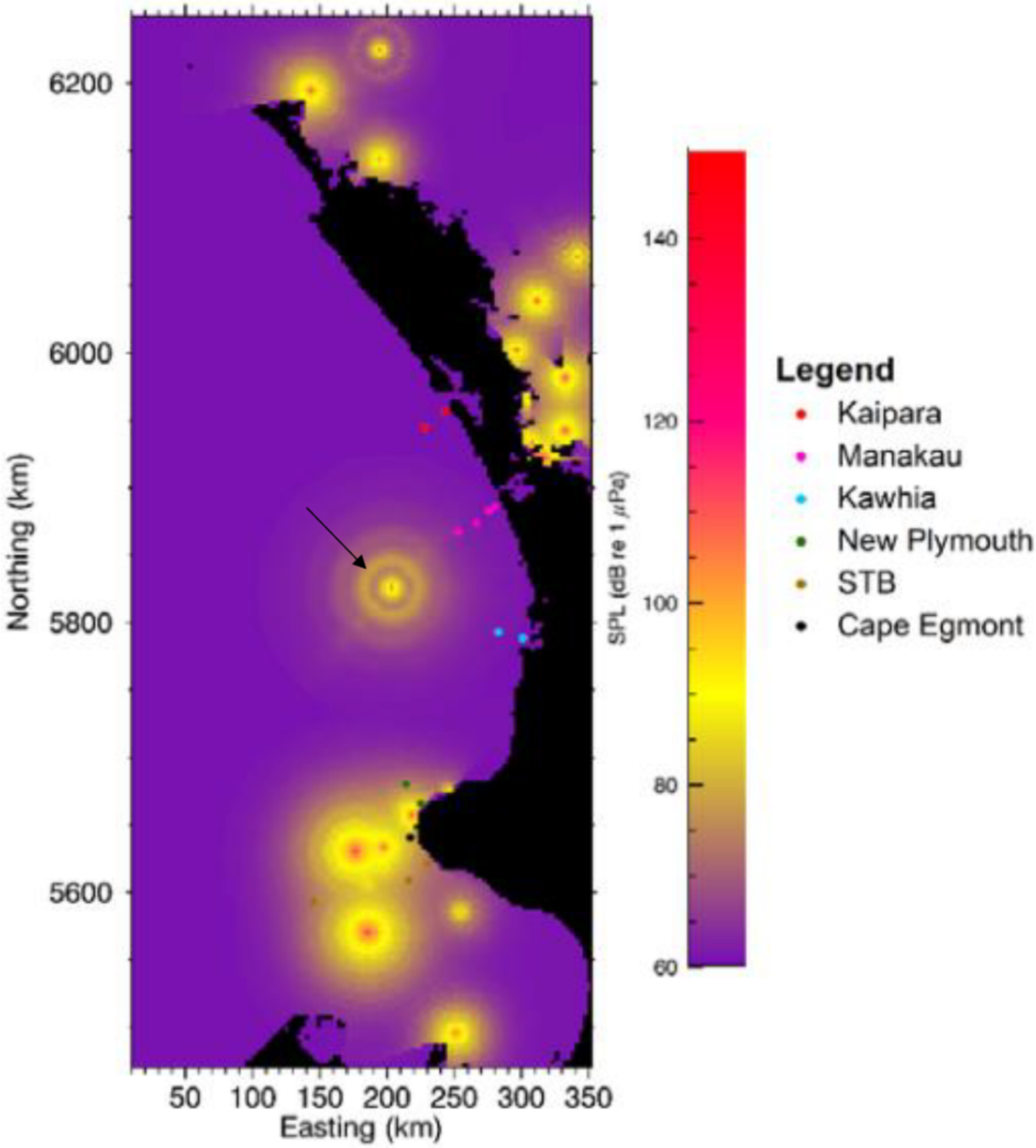
In order to better understand the potential risk from anthropogenic underwater noise on Māui’s dolphins, McPherson *et al* (2019) undertook sound recordings and sound propagation modelling of both seismic survey and vessel traffic noise on the west coast of the North island from July 2014 to June 2015. Key findings from this study are summarised below:

- Due to shipping traffic and proximity to existing oil and gas infrastructure, the predicted sound levels around New Plymouth (both at 2 and 12 NM offshore) were always greater than the baseline quiet noise level (below which the ambient noise level would be driven by non-anthropogenic sources). In comparison sound levels at sites north of Taranaki (Kawhia, Manakau and Kaipara) were predicted to be at or below the baseline quiet level for at least 75% of the time;
- High frequency weighted noise levels (i.e. those of relevance to Māui’s dolphins) were low to moderate in the vicinity of the proposed Turangi 3D Seismic Survey location even when offshore seismic surveys were in operation (**Figure 23** and **Figure 24**);
- The offshore seismic survey with sparsely spaced lines that occurred north of Taranaki during the study period only had a limited influence on inshore sound fields; where inshore vessel traffic had a greater, albeit sporadic, influence on this sound field;
- No seismic survey activity within the Marine Mammal Sanctuary was considered as part of this study; and
- Sound levels were consistently higher in winter months as propagation conditions at this time of the year favour lower attenuation rates and increased propagation ranges; hence noise sources have a larger footprint in colder months.

Given that the DOC Code of Conduct requirements act to manage the acoustic effects of seismic surveys to ‘as low as reasonably practicable’, the low power acoustic source and the short duration of the Turangi 3D Seismic Survey, the incremental contribution of this survey to cumulative effects (particularly on Māui’s dolphins) will be limited. Therefore, there are no specifically applicable additional mitigation measures available to address cumulative effects.

The significance of any residual cumulative effects from the Turangi 3D Seismic Survey is considered to be **minor**.

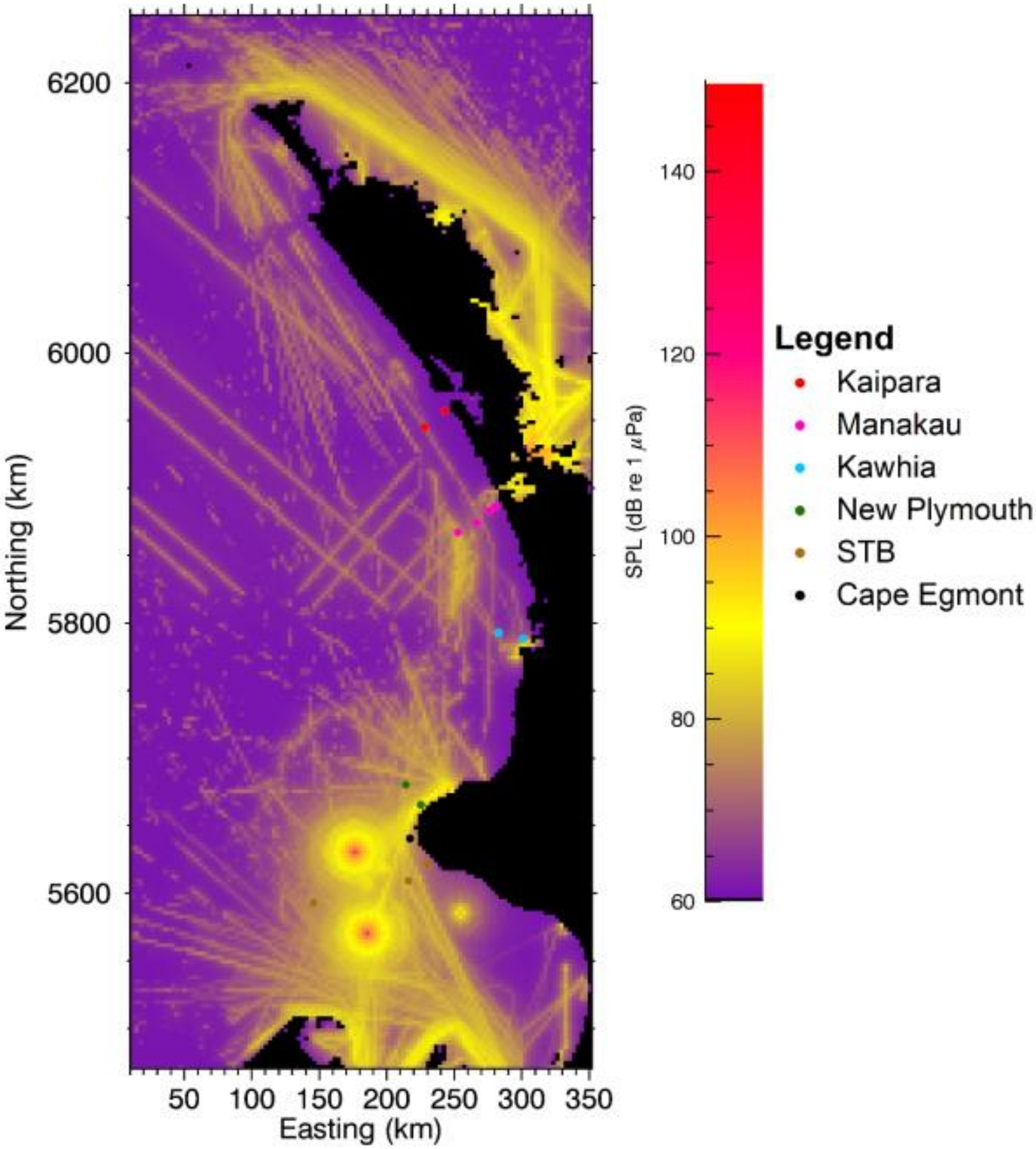
Figure 23 Time snapshot of high frequency weighted SPL for March 6 2015, showing the contribution of concurrent seismic surveys, multiple vessels, jackup platforms and FPSOs to the noise footprint recorded at the various receiver locations



Source: McPherson *et al.* (2019).

Note: SPL levels at the location marked with a black arrow are from the TGS Northwest Frontier Multiclient 2-D Marine Seismic Survey

Figure 24 One- month equivalent continuous underwater noise levels (L_{eq}) for March 2015: high frequency weighted SPL



Source: McPherson *et al*. (2019).

6.3 Unplanned Events

Unplanned events are rare during seismic survey operations; however, serious consideration must be given to the potential effects of any unplanned incident as consequences of such events can be severe. Unplanned events associated with operations may include equipment loss, or a vessel collision/sinking. These potential incidents are discussed below.

Note that the 'likelihood' assessment used for the unplanned events differs to that used for the planned events in that it is the likelihood of the activity occurring (compared to the likelihood of an effect occurring for planned events).

6.3.1 Potential Effects of Equipment Loss

The acoustic array proposed to be utilised for the Turangi 3D Seismic Survey will be towed behind the survey vessel. In the event that the acoustic source was lost, it would likely rapidly sink to the seabed. Upon contacting the seabed, the source could impact benthic communities; however, any effects would be highly localised.

The ocean bottom acquisition system will lie on the seabed, without surface buoys. These will be located and positioned with acoustic transponders. The tether attached will also have an acoustic transponder. It is unlikely that the ocean bottom acquisition system will be lost on the seabed as each node and tether will have acoustic transponders. If underwater visibility is at a workable state during retrieval the nodes will be retrieved by way of a small ROV attaching a tag line to these and winched to the surface. Alternatively, if poor visibility is encountered a grapple will be used to hook the tether line. The exact location of the tether will be calculated through the two acoustic transponders attached at each node location.

All activities carried out during the Turangi 3D Seismic Survey, including the deployment of the acoustic source and laying and retrieving the ocean bottom acquisition system, will be undertaken by experienced personnel using lifting equipment that is suitably rated and in current test status.

It is considered that the significance of any residual environmental effect from loss of equipment during the Turangi 3D Seismic Survey would be **negligible**.

6.3.2 Potential Effects from Vessel Collision or Sinking, and Release of Hazardous Substances

As the Primary Operational Area and Testing Area lie within a shared marine space, there is the potential for other marine users to interact with the survey vessel, with a collision at sea the biggest threat. If a vessel collision occurred, the biggest impacts would be damage to vessels, the release of harmful substances (e.g. diesel fuel), the release of debris into the marine environment, and harm to persons on-board the stricken vessel/s.

In the event of a vessel collision, the integrity of the hull of the vessel/s may be compromised, leading to the release of diesel fuel into the marine environment. Due to the proximity of the Primary Operational Area and Testing Area to the coast, any released substances may reach the shoreline. In general, the effects of contamination by hydrocarbon products (such as diesel) on marine organisms fall into five categories (Moore & Dwyer, 1974):

- Direct lethal toxicity;
- Sub-lethal disruption of physiological and behavioural activities (particularly feeding and reproductive behaviours);
- Effects of direct coating;

- Incorporation of hydrocarbons (i.e. bioaccumulation) in the food chain and tainting of edible organisms; and
- Alteration of habitats (leading to shifts in species composition and geographic distribution).

Cetaceans are less sensitive to external contamination by hydrocarbons on account of their smooth skin and thick blubber layer for insulation. As fur seals rely solely on the integrity and health of their fur for waterproofing and insulation, they are highly susceptible to external oiling which can cause significant thermoregulatory and buoyancy effects (OWCN, 2004).

Seabirds rely on their plumage for flight, insulation and buoyancy (O'Hara & Morandin, 2010). Hydrocarbon contamination of plumage is the primary cause of mortality in seabirds exposed to spills (Leighton, 1991). Contamination disrupts the structure of the feather which, when functioning correctly, block the penetration of water (O'Hara & Morandin, 2010). Water-logged feathers lead to dehydration and exhaustion in affected birds (Balseiro *et al*., 2005). Foraging strategy plays an important role in the vulnerability of seabirds to oil contamination with species that feed by diving or swimming on the sea surface (e.g. penguins, shags and gannets) more vulnerable to contamination than species that pluck prey from the surface during flight (Williams *et al.*, 1995).

Internal contamination from ingested hydrocarbons can cause various toxicological effects in animals. Common physiological effects form internal contamination include dehydration, anaemia, organ damage, intestinal ulceration, immunosuppression, irritations and burns to mucous membranes, and aspirate pneumonia (Balsiero *et al.*, 2005).

Volatile polycyclic aromatic hydrocarbons with lower molecular weights (e.g. light fuel oil such as diesel) are more readily bioavailable and toxic than heavier polycyclic aromatic hydrocarbons (e.g. crude oil). As PAHs are fat-soluble exposed marine mammals tend to accumulate them over the short-term in lipid-rich organs before they are eliminated by metabolism and excretion (Troisi *et al*., 2007). Hydrocarbons may accumulate in fish tissues through the transport of contaminants across cell membranes of their skin and gills, or in their diet through the ingestion of contaminated food (Moe *et al*., 1994). Contaminants are transported through the blood to body organs where they can accumulate at several thousand times the concentration of surrounding water (Ansari *et al.*, 2012). Although the accumulation of hydrocarbons in fish tissues is temporary due to their ability to metabolise PAHs (Lawrence & Weber 1984), the rate of accumulation and excretion is species-dependent (Neff *et al.*, 1976). The ability of invertebrates to metabolise PAHs is generally markedly lower than in vertebrates; invertebrates accumulate a wider range of PAHs due to their lower ability to metabolise xenobiotic compounds (Neff & Burns, 1996). Armstrong *et al.* (1995) suggested that bioaccumulation of hydrocarbons is particularly significant in bivalves, because they completely lack the ability to metabolise and excrete PAHs (Eisler, 1987).

Due to the coastal nature of the Primary Operational Area and Testing Area, bioaccumulation of hydrocarbons in tissues and tainting of edible flesh in species harvested for human consumption would be of concern. Potential effects of a spill on fisheries include effects on fish populations, contamination of equipment (e.g. nets and boats), displacement from fishing grounds, contamination of catch, loss of revenue from disruption, and negative public perception of fish quality and safety.

The survey vessel will adhere to all relevant safety requirements as per international regulations and conventions (e.g. COLREGS) while carrying out works for the Turangi 3D Seismic Survey, including the display of relevant lights and day shapes, and monitoring of VHF radio. Due to the presence of the Pohokura platform in the vicinity of the Primary Operational Area and Testing Area and the Taranaki Bight Precautionary Area, all marine users should be aware of potential hazards in the area and navigate the area with caution. Use of the Primary Operational Area by other marine users is not expected to be high (as it does not like in the path of any major shipping lanes), and presence of the survey vessel will not significantly increase the risk of collision to other marine users.

Based on the information presented above and the mitigation actions in place, it is considered that the significance of residual effects associated with vessel collision/sinking and subsequent release of hazardous substances during the Turangi 3D Seismic Survey are **minor**.

6.4 Environmental Risk Assessment Summary

Table 17 provides a summary of the Environmental Risk Assessment results.

Table 17 Summary of potential residual effects and significance

Effects from Planned Activities	Significance
Physical presence of survey vessel and acoustic source – effects on marine mammals.	Negligible
Physical presence of survey vessel and acoustic source – effects on seabirds.	Negligible
Physical presence of survey vessel and acoustic source – effects on benthic fauna.	Negligible
Physical presence of survey vessel and acoustic source – effects on other marine users.	Negligible
Acoustic disturbance – physiological effects on zooplankton.	Minor
Acoustic disturbance – physiological effects on benthic invertebrates.	Negligible
Acoustic disturbance – physiological effects on cephalopods.	Negligible
Acoustic disturbance – physiological effects on fish.	Negligible
Acoustic disturbance – physiological effects on marine reptiles.	Negligible
Acoustic disturbance – physiological effects on seabirds.	Negligible
Acoustic disturbance – physiological effects on marine mammals.	Moderate
Acoustic disturbance – behavioural effects on benthic invertebrates.	Negligible
Acoustic disturbance – behavioural effects on cephalopods.	Minor
Acoustic disturbance – behavioural effects on fish and commercial fisheries.	Minor
Acoustic disturbance – behavioural effects on marine reptiles.	Negligible
Acoustic disturbance – behavioural effects on seabirds.	Minor
Acoustic disturbance – behavioural effects on marine mammals.	Moderate
Acoustic disturbance – perceptual effects on fish.	Minor
Acoustic disturbance – perceptual effects on marine mammals.	Moderate
Acoustic disturbance – indirect effects	Minor
Waste discharges and emissions – biodegradable waste	Negligible
Waste discharges and emissions – non-biodegradable waste	Negligible

Effects from Planned Activities	**Significance**
Waste discharges and emissions – atmospheric emissions	Negligible
Cumulative effects	Minor
Effects from Unplanned Events	
Effects from equipment loss	Negligible
Effects from vessel collision or sinking	Minor

7 Conclusion

The Turangi 3D Seismic Survey is planned as a transitional seismic survey to fill a data gap between an existing marine 3D seismic survey and land-based 3D seismic survey. This survey will utilise a boat-based acoustic source with an effective total volume of 1,000 or 1,420 in^3 and an ocean bottom acquisition system. Two operational areas are proposed; these being the Primary Operational Area along the coastline of Onaero, North Taranaki and a 1 km x 1 km acoustic source Primary Operational Area and Testing Area off New Plymouth. The acoustic source will only be operated within these two defined areas. However, in order to determine the potential environmental effects of the Turangi 3D Seismic Survey, a broader AOI has been assessed which encompasses both the Primary Operational Area and Testing Area. It is noteworthy that both areas are located within the boundaries of the West Coast North Island Marine Mammal Sanctuary.

During the Turangi 3D Seismic Survey, NZSL will comply with the Level 1 requirements of the Code of Conduct as the primary means of mitigating any potential environmental effects arising from the surveys. By complying with the mitigation measures required by the Code of Conduct, the potential effects of acoustic disturbance on marine mammals will be minimised to a level that is deemed acceptable by DOC. In order to ensure compliance with the standard mitigation zones, STLM has been conducted, ensuring that the mitigation zones are sufficiently large to protect marine mammals from physiological effects during the Turangi 3D Seismic Survey. The STLM short range modelling predicts that the maximum received SELs will easily comply with the limits of 186 dB re 1 $\mu Pa^2 \cdot s$ at 200 m, and 171 dB re 1 $\mu Pa^2 \cdot s$ at 1.0 km; indeed levels of compliance to these SEL thresholds will be reached much closer to the source (at worst 50 m and 400 m respectively if the 1,000 in^3 source is utilised).

As per the Code of Conduct, there will be two MMOs and two PAM Operators onboard the source vessel to monitor for and detect the presence of marine mammals. These personnel will be independent and qualified through DOC approved training programmes. Detections of marine mammals within the mitigation zones will trigger the required mitigation action (e.g. delayed starts or shut-downs of the acoustic source).

In addition to compliance with the Code of Conduct and the above-mentioned mitigation measures, NZSL will implement additional mitigation measures due to the coastal and sensitive nature of the Primary Operational Area and Testing Area.

This MMIA has identified all the potential environmental effects that may arise from the Turangi 3D Seismic Survey and describes the mitigation measures that NZSL will implement to ensure that any potential effects are reduced to levels that are as low as reasonably practicable. While this MMIA focuses on potential effects on marine mammals, effects on other environmental and socio-economic receptors have also been considered. The following mitigation measures will be employed by NZSL during the duration of the Turangi 3D Seismic Survey to mitigate against any potential effects:

- Seismic acquisition will only occur during daylight hours;
- Compliance with the Code of Conduct including the following key points:
    - Two MMOs and two PAM Operators will be stationed on the source vessel to maintain watch for marine mammals;
    - Two MMOs and at least one PAM Operator will be on duty at all times when the acoustic source is in the water;

  - The standard mitigation zones within the Code of Conduct will be used for delayed starts and shut-downs. STLM has confirmed that the survey complies with the regulatory mitigation zone SEL requirements defined within the Code of Conduct;
  - Pre-start observations from the source vessel will be carried out for at least 30 minutes prior to activating the acoustic source. The acoustic source will only be activated in the event that no marine mammals (other than New Zealand fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no New Zealand fur seal has been observed in the relevant mitigation zone for at least 10 minutes;
  - In line with the requirements of the Code of Conduct for start-up in a new location, additional pre-start observation requirements will be implemented at the commencement of each day's operations if sighting conditions are poor;
  - If a marine mammal is observed within the relevant mitigation zone, the acoustic source will be shut-down or start-up will be delayed until the MMOs confirm the animal has left the mitigation zone for the required period of time; and
  - Activation of the acoustic source will only occur following the soft-start procedures after the above observation period.
- Compliance with all required and relevant regulations and conventions (e.g. COLREGS and MARPOL) to ensure safety of all crew and other marine users and to avoid adverse effects on the marine environment from potential discharges and vessel collisions;

In addition to the above mitigation measures, the following commitments have been made:

- Immediate notification to DOC of any Hector's/Māui's dolphin sightings;
- DOC Taranaki staff will be notified in advance of the days when the acoustic source is likely to be active to allow a fast response to any Māui's/Hector's dolphin sightings;
- Vessel crew onboard the survey vessels will at all times remain vigilant for sightings of little blue penguins. Observations of little blue penguins will be included in daily observations and reported alongside the required marine mammal observations; and
- In the event that a stranding occurs in the AOI during the survey, or within two weeks following the completion of each survey NZSL will, on a case-by-case basis, consider covering the cost of a necropsy in an attempt to determine the cause of death. NZSL will seek advice from DOC as to the requirement for a necropsy.

Overall, the predicted effects of the Turangi 3D Seismic Survey are considered to be sufficiently managed by the proposed mitigation measures, predominantly compliance with the Code of Conduct and restriction of acoustic operations to daylight hours. STLM demonstrates that physiological effects would only occur out to 400 m from the acoustic source, in comparison, the mitigation zones prescribed by the Code of Conduct will be highly protective to marine mammals. While some behavioural effects and masking may occur beyond 400 m, the short duration of the survey and the relatively low level of use of the Primary Operational Area and Testing Area by marine mammals reduces the possibility of these effects being of any ecological significance.

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APPENDIX A

Sound Transmission Loss Modelling

TURANGI 3D SEISMIC SURVEY

Sound Transmission Loss Modelling

Prepared for:

NZ Surveys 2020 Limited
Level 9
151 Queen Street
Auckland

SLR Ref: 740.30001-R01
Version No: -v1.0
October 2020

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with NZ Surveys 2020 Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.30001-R01-v1.0	28 October 2020	Dana Lewis, Binghui Li	Binghui Li	Dan Govier

EXECUTIVE SUMMARY

NZ Surveys 2020 Limited (NZSL) proposes to undertake a 3D seismic survey within the proposed Turangi 3D Seismic Survey Operational Area. SLR Consulting New Zealand Pty Ltd (SLR) has been engaged by NZSL to provide Sound Transmission Loss Modelling (STLM) services for the proposed 3D seismic survey. The survey area is directly offshore the west coast of the North Island of New Zealand in the North Taranaki Bight and lies within the West Coast North Island marine mammal sanctuary.

This report details the sound transmission loss modelling 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 requirements, and
- Long range modelling, i.e. prediction of the received SELs over a range of up to 100 km from the array source location, in order to assess the noise impact from the survey on the surrounding marine mammal sanctuaries or other areas of marine importance.

The detailed modelling methodologies and procedures for the above components are described in **Section 2** and **Section 3** of the report.

The proposed acoustic source for this survey is a 720 cubic inch (CUI) array. The source array comprises 2 subarrays, and each subarray has four source elements. The average towing depth for the source array is 2.5m, and it has an operating pressure of 2000 pounds per square inch (PSI).

The deepest location within the survey area (with a water depth of approximately 20 m) was chosen for both the short and long range modelling scenarios. The worst-case environmental conditions, i.e. winter seasonal sound speed profile and fine sand seabed sediment, have been assumed for the modelling cases.

The short range modelling prediction demonstrates that the highest SELs occur in the in-line and cross-line directions, as a result of the directionality of the source array. The maximum received SELs over all azimuths are predicted to be below the injury threshold 186 dB re 1µPa^2·s at 200 m and the behavioural threshold 171 dB re 1µPa^2·s at 1.0 km respectively.

The long range modelling shows that the received noise levels at long range vary significantly at different angles and distances from the source. This directionality 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. From the source location towards the adjacent shallower water shoreline directions, sound energy has strong interaction with the upslope seabed which consequently induces strong attenuation. The received SELs are predicted to be as low as 130 dB re 1µPa^2·s 5 km away from the array source location. To the offshore directions along continental shelf regions, the sound energy initially interacts with downslope seabed, and then is predominantly trapped within the surface sound duct with the depth increases, and as a result has limited energy loss due to less interaction with the sea surface and the seabed. At cross-line directions to the north and the east, the received SELs are predicted to be up to 110 dB re 1µPa^2·s even 100 km away from the array source location.

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APPENDICES

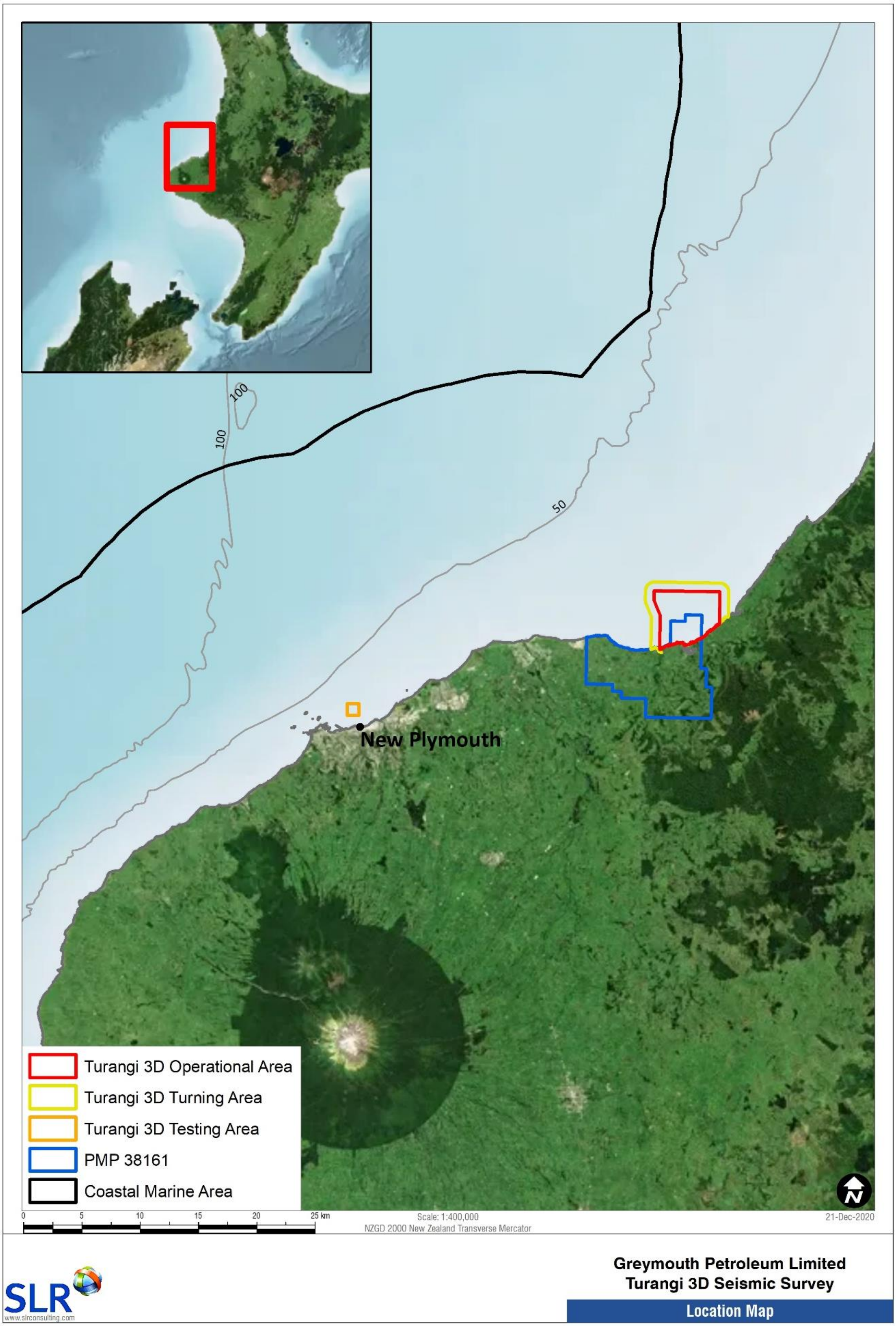
1 Introduction

1.1 Project description

NZ Surveys 2020 Limited (NZSL) proposes to undertake a 3D seismic survey within the proposed Turangi 3D Seismic Survey Operational Area, as shown in **Figure 1**. The survey area is directly offshore the west coast of the North Island of New Zealand in the North Taranaki Bight. The full-fold acquisition area lies from the coastline to up to 5km off the coastline with the operational area to up to 5.75 km offshore. The proposed survey area lies within the West Coast North Island marine mammal sanctuary.

SLR Consulting NZ Ltd (SLR) has been engaged by NZSL to undertake sound transmission loss modelling (STLM) for the proposed surveys, in order to predict the received sound exposure levels (SELs) from the survey, and to demonstrate whether the survey complies with the sound exposure level statutory requirements within the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code).

Figure 1 The proposed North Taranaki Seismic Survey Operational Area outlined in red. Larger yellow area is the turning area



1.2 Statutory requirement 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 sound transmission loss modelling to be undertaken to determine whether received SELs exceed 171 dB re 1µPa^2.s (the behavioural threshold) at ranges of 1.0 km and 1.5 km from the source or 186 dB re 1µPa^2.s (the injury threshold) 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 over 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 surrounding marine mammal sanctuaries or other areas of marine importance.

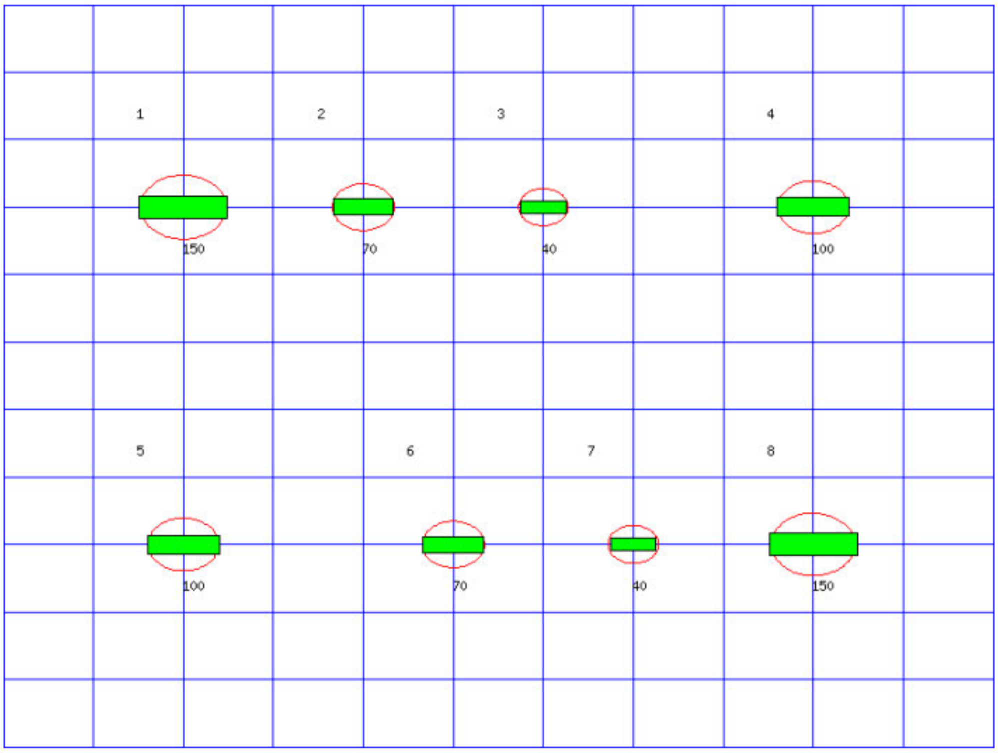
Section 2 of this report details the modelling methodology, procedure and results for the array source modelling. **Section 3** of the report outlines the methodologies and procedures associated with the short and long range transmission loss modelling, with the major modelling results presented in **Section 4.**

2 Seismic Airgun Array Source Modelling

2.1 Airgun array configuration

The airgun array for the Turangi 3D Seismic Survey is proposed to be a 720 CUI source array with configuration shown in **Figure 2**. The array consists of 8 active 1900LLXT airgun units, has a towing depth of 2.5 m and an operating pressure of 2 000 pounds per square inch (PSI).

Figure 2 The configuration of the 720 CUI source array



2.2 Modelling methodology

The outputs of the 720 CUI array source modelling include:

- A set of “notional” signatures for each of the array elements; and
- The far-field signature of the array source, including its directivity/beam patterns.

2.2.1 Notional signature

The notional signatures are the pressure waveforms of individual source elements at a standard reference distance of 1 m.

Notional signatures are modelled using the Gundalf Designer software package (2020). The Gundalf source model is developed based on the fundamental physics of the oscillation and radiation of source bubbles as described by Ziolkowski (1970), and for an array source case, taking into account non-linear pressure interactions between source elements (Ziolkowski et al., 1982; Dragoset, 1984; Parkes et al., 1984; Vaage 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 source elements and interacting clusters for all common source types at a wide range of deployment depths.

The model has the capability to predict noise spectra with frequency range up to tens of kHz. For frequencies above 1 kHz, the modelled spectra generally follow a close to *1/f* attenuation (Landrø et al, 2011). As the noise emissions from an airgun array are predominantly below hundreds of Hz, the following result section only demonstrates modelling results within frequency range below 1 kHz.

2.2.2 Far-field signatures

The notional signatures from all airguns 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:

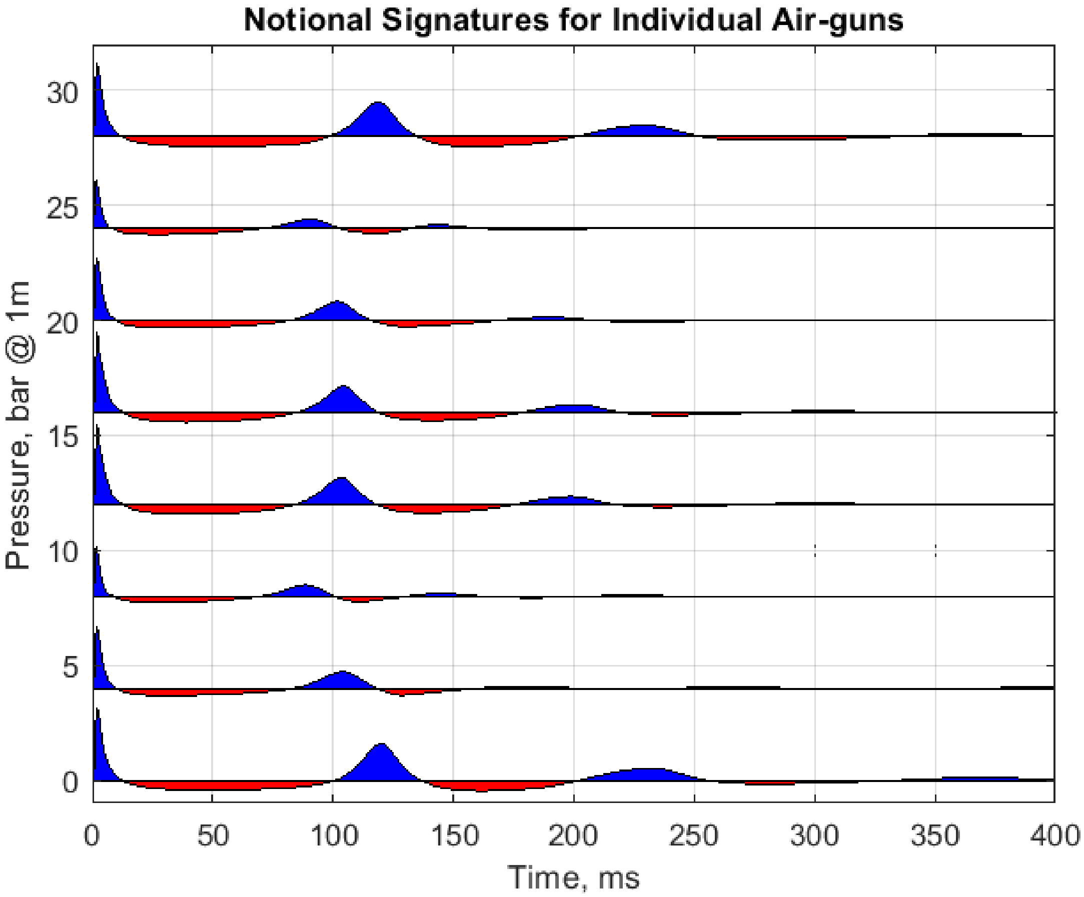
- The far-field signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The PSD (dB re 1 µPa^{2}s/Hz @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of all resulting signature waveforms 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 source signatures for the 8 airgun array elements. Each line within the figure represents the notional source signature of the corresponding array element as shown in **Figure 2**.

Figure 3 Notional source signatures for the 720 CUI source array

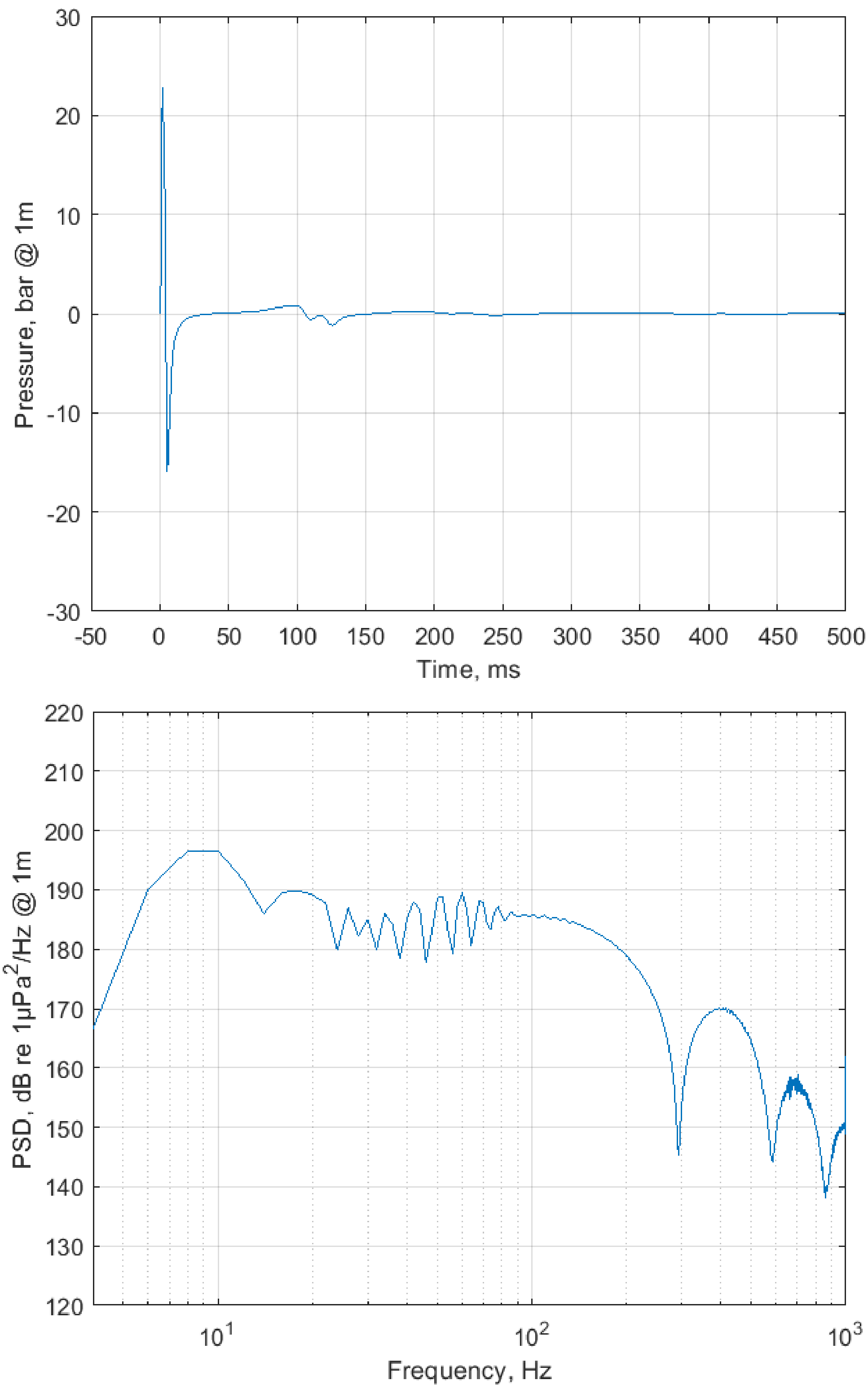


2.3.2 Far-field signature and its power spectral density

Figure 4 shows the far-field signature waveform and its power spectral density simulated by the Gundalf Designer software. The signatures are for the vertically downward direction with surface ghost included.

The source modelling result shows that the peak sound pressure level (Pk SPL) is 247.1 dB re 1 µPa @ 1m, the root-mean-square sound pressure level (RMS SPL) 235.8 dB re 1 µPa @ 1m with a 90%-energy pulse duration of 12.5 milliseconds, and the sound exposure level (SEL) 222.0 dB re µPa^2·s @ 1m.

Figure 4 **The far-field signature in vertically downward direction (top) and its power spectral density (bottom) for the 720 CUI source array**



2.3.3 Beam patterns

Array far-field beam patterns of the following three cross sections are presented in **Figure 5**:

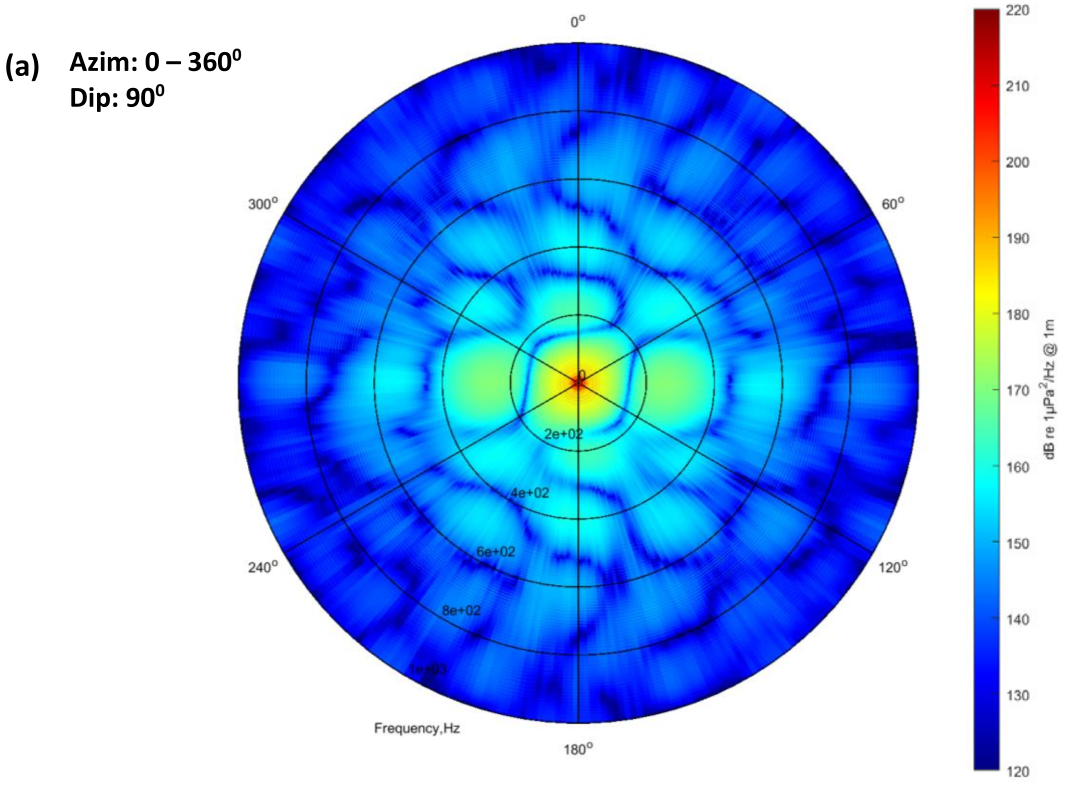
a) The horizontal plane (i.e. dip angle of 90 degrees) with azimuthal angle of 0 degree corresponding to the in-line direction;

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

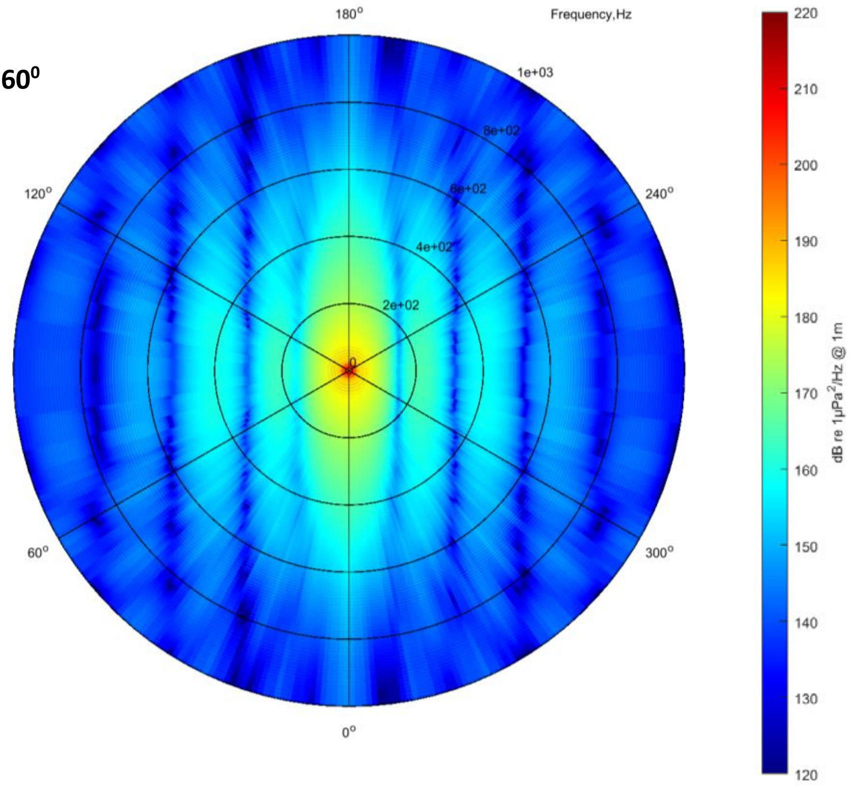
c) The vertical plane for the cross-line direction (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

The beam patterns in **Figure 5** illustrate 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 have the strongest radiation in the vertical direction.

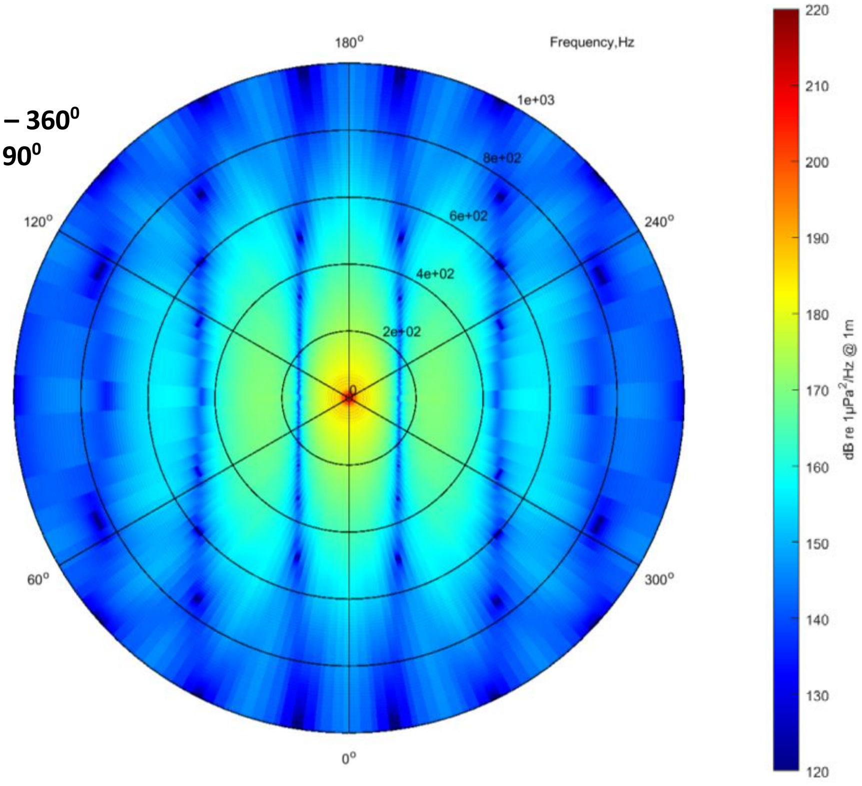
Figure 5 Array far-field beam patterns for the 720 CUI source array, as a function of orientation and frequency. (a) - The horizontal plane with 0 degree corresponding to the in-line direction; (b) – The vertical plane for the in-line direction; (c) – The vertical plane for the cross-line direction. 0 degree dip angle corresponds to vertically downward direction



(b) Dip: 0 – 360^0
Azim: 0^0



(c) Dip: 0 – 360^0
Azim: 90^0



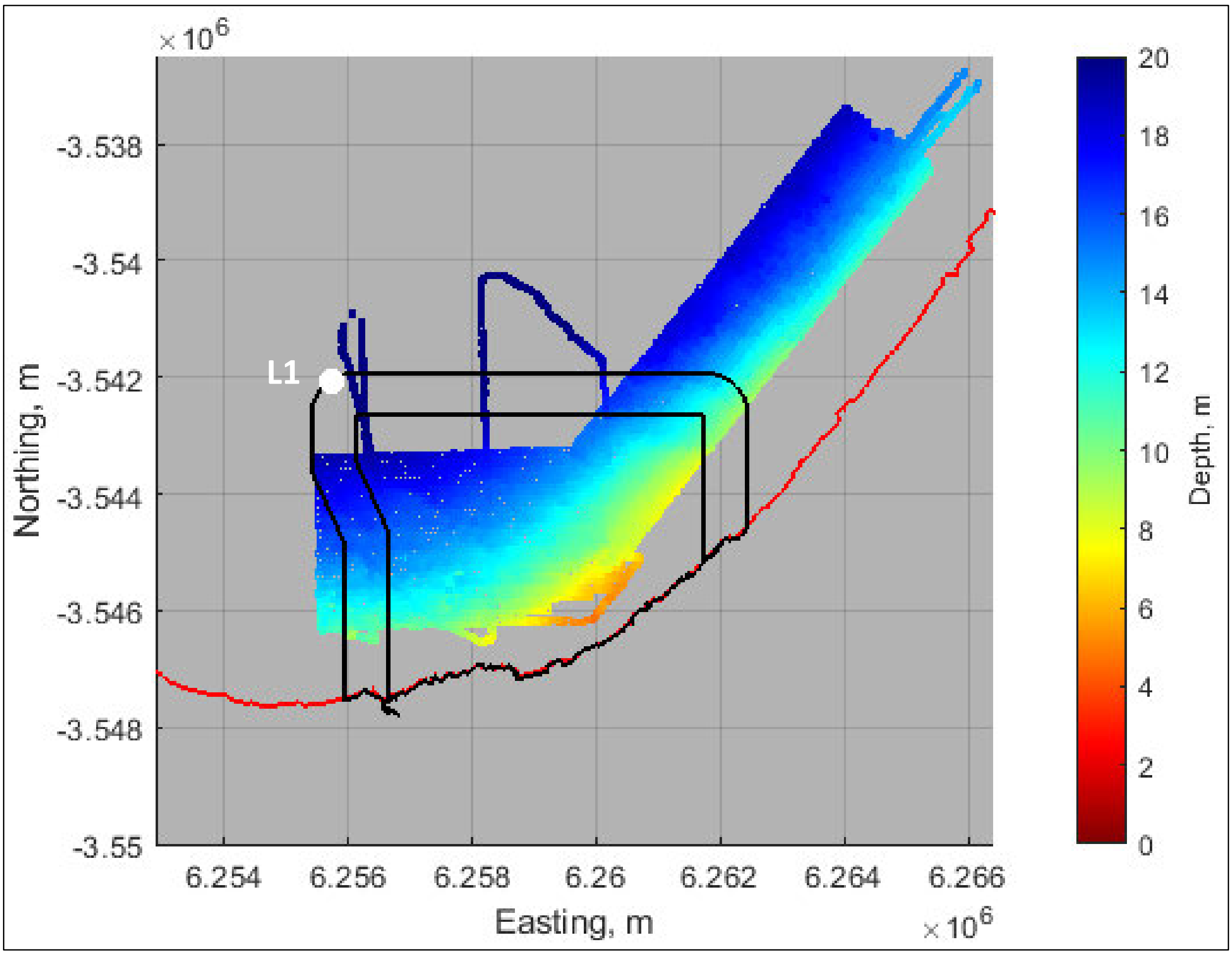
3 Transmission Loss Modelling

3.1 Modelling input parameters

3.1.1 Bathymetry

The bathymetry dataset provided by NZSL, as can be seen in **Figure 6**, does not cover the full extent of the survey area and the surrounding offshore region required for the modelling study. It can be determined from this dataset that the deepest point within the survey area is at the northwest corner, represented as L1 in the figure. This will be the location used for both the short and long range modelling scenarios.

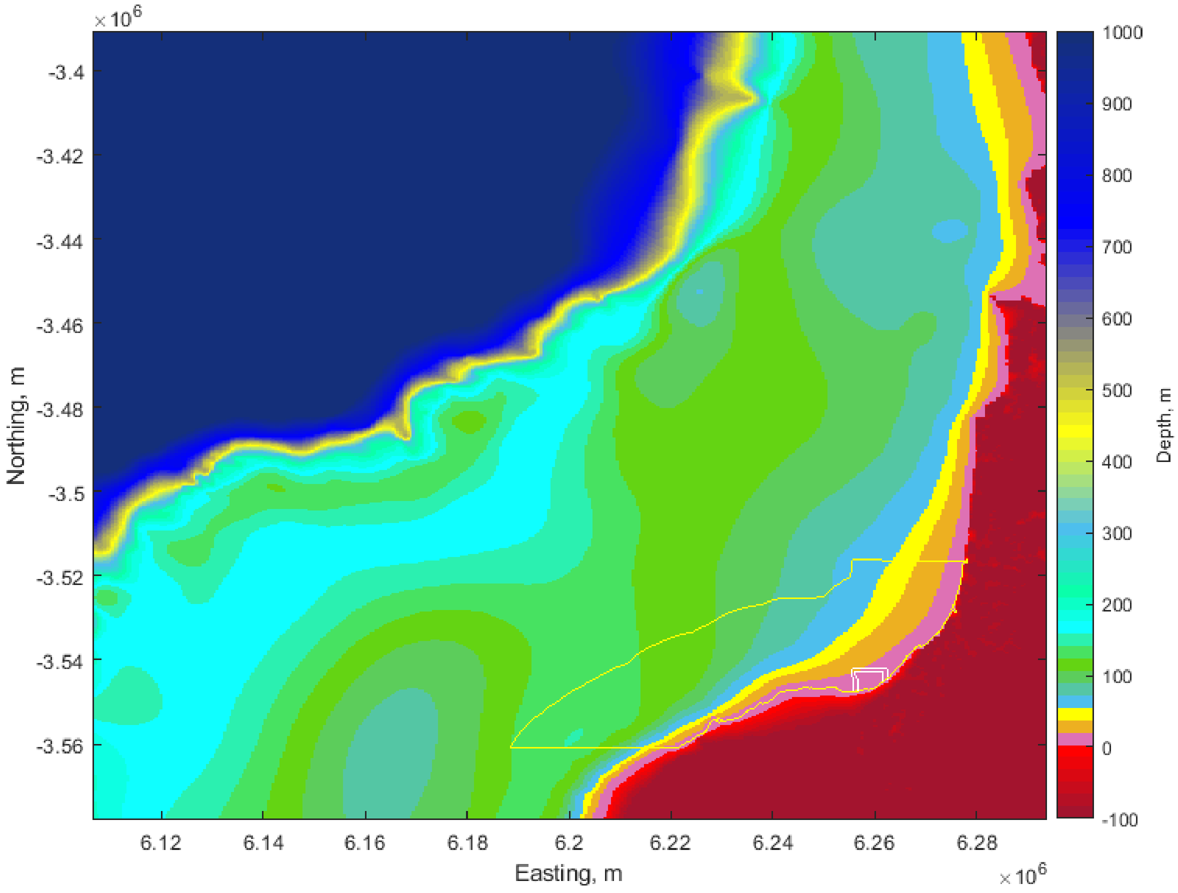
Figure 6 Bathymetry dataset provided. Black polygons represent the full-fold acquisition area and the operational area. Red line represents the Taranaki coastline. White dot represents deepest location within the survey area. Coordinates in WGS 84 Mercator 41 Projection.



The full bathymetry dataset used for the sound propagation modelling was obtained from the National Institute of Water and Atmospheric Research (NIWA) NZ Region 250 m gridded bathymetric dataset (CANZ, 2008).

This dataset showed some differences to the provided bathymetry dataset, especially close to the coastline. This could be due to tidal height variation throughout the region. As such, the NIWA dataset has been adjusted to reflect the same depth for the two datasets at L1 as the provided dataset. The adjusted dataset is as shown in **Figure 7**.

Figure 7 Bathymetry dataset covering the extended area surrounding the survey location for the model input. Coordinates in WGS 84 Mercator 41 Projection.

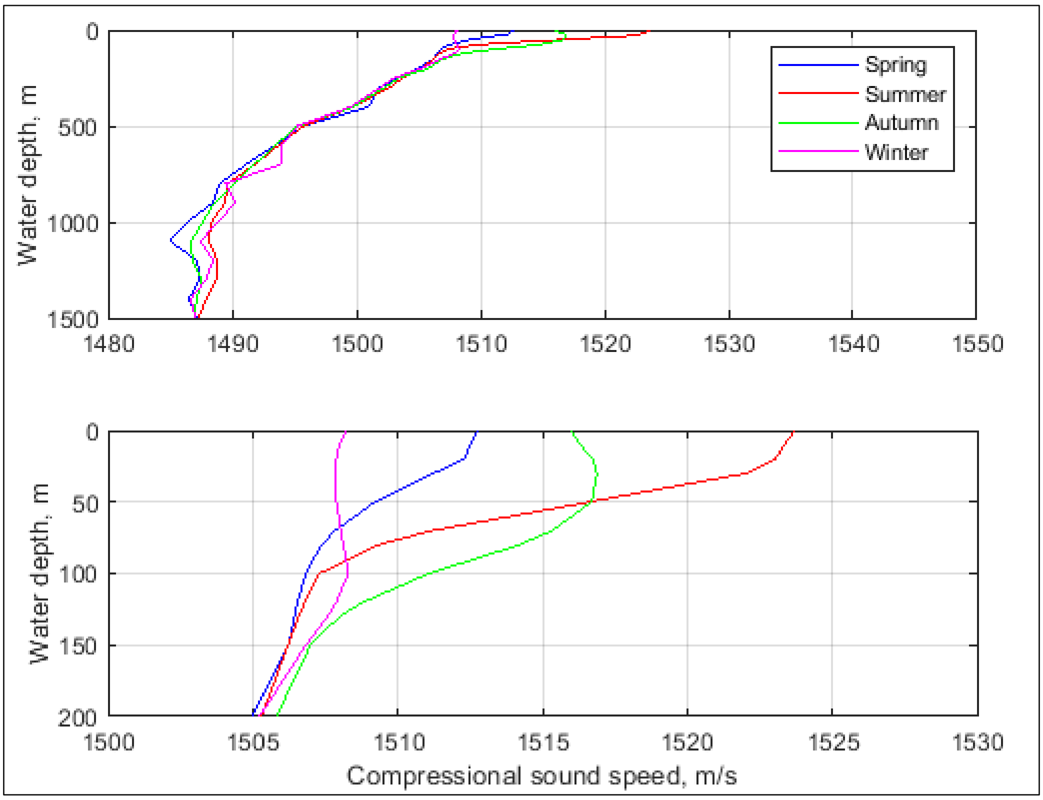


3.1.2 Sound speed profile

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 needed for calculation of the sound speed based on depth and latitude of each particular sample 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 8 presents the typical sound speed profiles for four seasons within the near shore shallow water area as well as the deep water continental slope region. The figure demonstrates that the most significant distinctions for the profiles of four seasons occur within the mixed layer near the surface. The summer season has the strongest downwardly refracting feature among the four seasons, and the winter season exhibits a relatively deeper surface duct than the other three seasons. 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. Therefore, based on a conservative consideration, the winter season sound speed profile is selected as the modelling input.

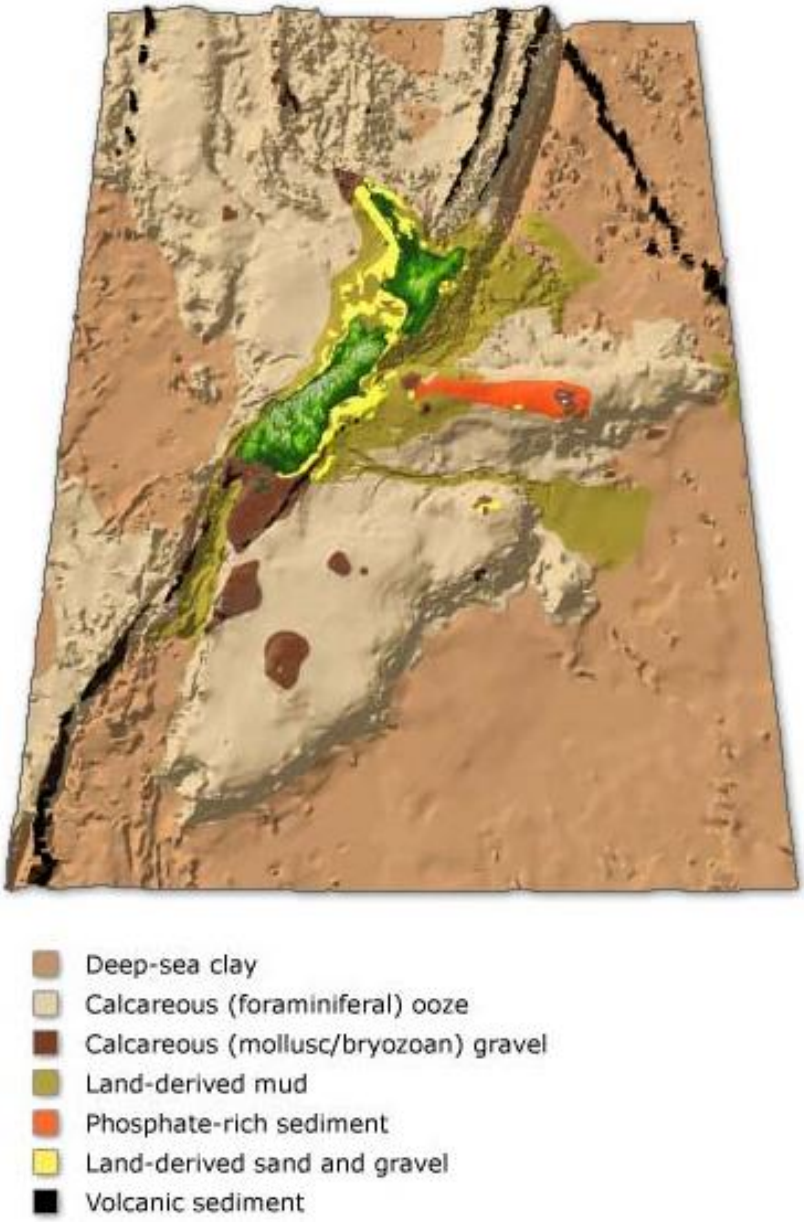
Figure 8 Typical sound speed profiles within the near shore shallow area (bottom) and offshore continental slope region (top) for four different seasons.



3.1.3 Seafloor geoacoustic model

New Zealand has diverse seafloor sediments thanks to its variable and dynamic marine and terrestrial environments. NIWA has over many years produced a variety of marine sediment charts illustrating the ocean bottom types around coastal New Zealand and some offshore areas. The map in **Figure 9** 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 9 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 western North Island, areas of black iron-rich sand have been formed by wave action on volcanic rock.

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. such as Matthew et al (2014) and Galindo-Romero et al (2014)). A summary of sediment types in and around the Taranaki Basin is provided in **Table 1**.

Table 1 Detailed sediment types within the Northern Taranaki coastal and offshore regions.

Region – **Northern Taranaki**	Sediment Type
Taranaki – Northland Continental Shelf	Dominant fine sand sediment with coarse sand sparsely scattered
Taranaki – Northland Continental Slope	Silt - clay

The geoacoustic properties for the various possible sediment types within the coastal and offshore regions around the project area are presented in **Table 2**. The geoacoustic properties for sand, silt and clay are as described in Hamilton (1980), with attenuations referred to 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 in the Taranaki Basin.

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 10** and **Figure 11** respectively. As can be seen, the sandy seafloor sediments are more reflective than the silt and clay sediments, particularly at low grazing angles. Based on the sediment distribution in and around the survey area as indicated above, fine sand will be used as the seabed sediment input for the modelling scenario. Due to its acoustically reflective characterises, sandy seabed also represents a conservative sediment input option.

Figure 10 The reflection coefficients (magnitude - top panel and phase – bottom panel) for sand sediments (coarse sand, fine sand and very fine sand)

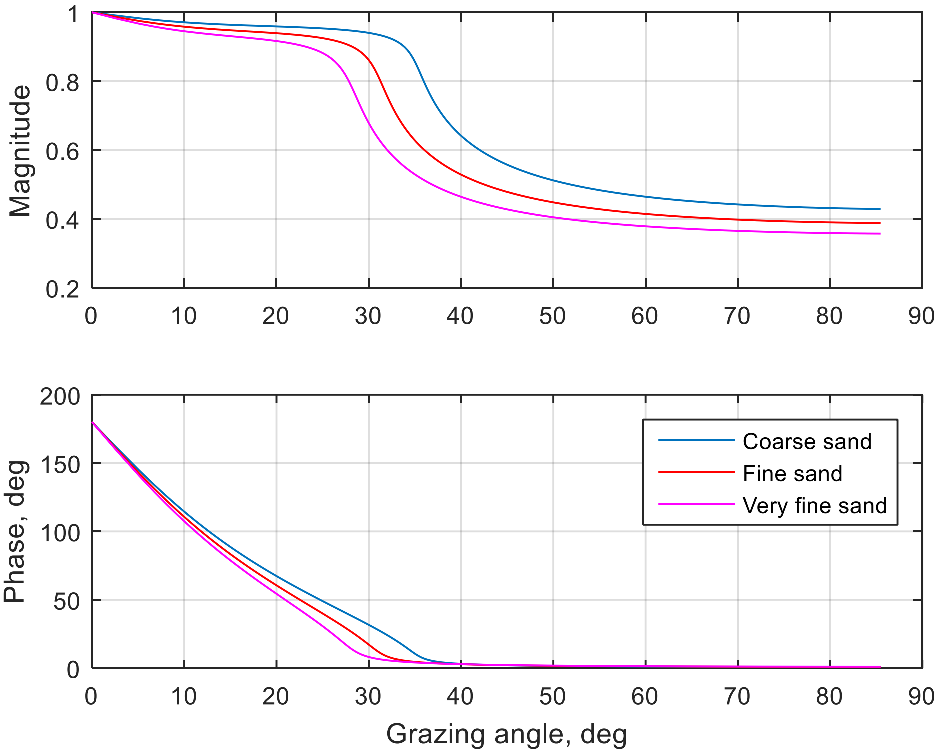
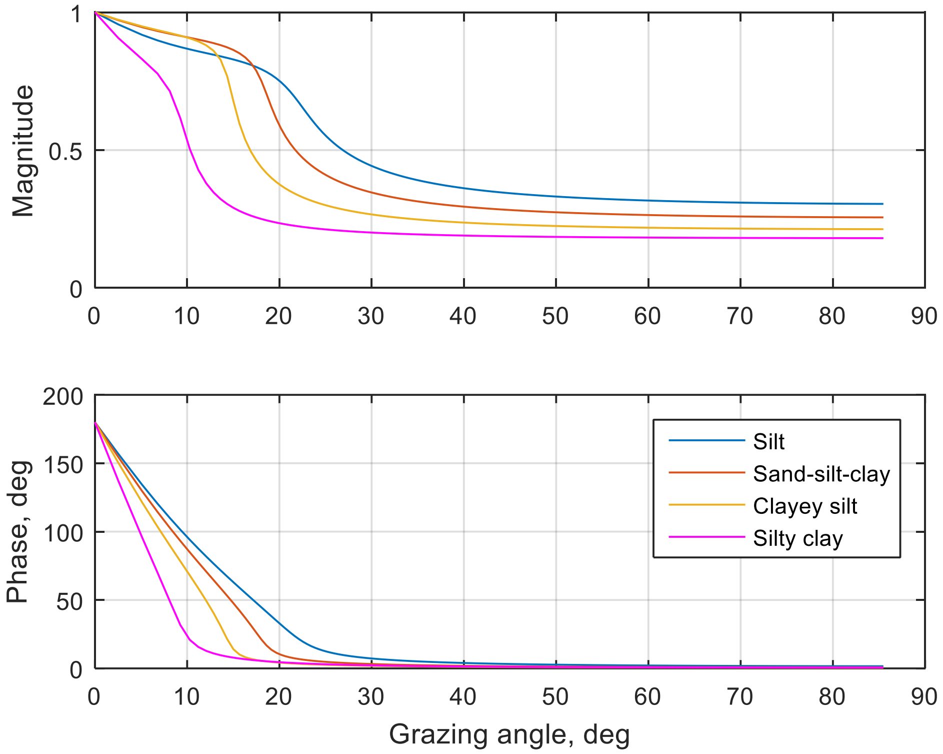


Figure 11 The reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay)



3.2 Detailed modelling methodologies and procedures

The modelling accuracy requirements, 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

Short range modelling has been used to model received SELs in relatively close proximity to the airgun source, with consideration of the near-field effect of the sound field. As such, 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 procedures have been followed to calculate received SELs for short range cases:

1. The modelling algorithm SCOOTER is executed for frequencies from 1 Hz to 1 kHz, in 1 Hz increments. The source depth is taken to be the array depth of 2.5 m. A receiver grid of 1 m in range (maximum range 2.0 km) and 0.1 m in depth is applied for the selected receivers. For each gridded receiver, the received SEL is calculated by following steps 2) – 5);
2. The range from the source to each receiver is calculated, and the transfer function between the 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 signal waveform in frequency domain;
3. The complex frequency domain signal of the notional signature waveform for each source element 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 the source element;
4. The waveform of received signal from the array source is reconstructed via Inverse Fourier Transform. The received signal waveforms from all airgun sources in the array are summed to obtain the overall received signal waveform; and
5. The signal waveform is squared and integrated over time to obtain the received SEL value. Alternatively, the SEL value can also be calculated via integration of the energy power density (ESD) over frequency in Step 3).

3.2.1.2 Modelling scenarios

The worst case modelling conditions for underwater noise propagation applicable to the proposed survey, i.e. fine sand seabed sediment and winter season sound speed profile, have been assumed for the short range modelling. The location modelled has an approximate depth of 20 m and details can be seen in **Table 3** and as Location 1 (L1) in **Figure 6**.

Table 3 Details of the selected single source location for the short and long range modelling

Source Location	Water Depth, m	Coordinates [Easting, Northing]	Locality
L1	~ 20	[6.2557 x 10^5, -3.5421 x 10^6]	Northwest boundary corner point of the proposed area, with the **deepest water depth** over the entire survey area.

3.2.2 Long range modelling

3.2.2.1 Modelling methodology and procedure

The long range modelling generally involves complex and variable environmental factors (such as sound speed profiles and bathymetric variations) along an extended range of sound propagation environments, and requires an efficient modelling prediction algorithm with reasonable accuracy. Therefore, the modelling prediction for the long range case is carried out using the far-field source levels of one-third 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 geo-acoustic properties.

The received sound exposure levels are calculated following the procedure as below:

1) One-third octave source levels for each azimuth to be considered are obtained by integrating the horizontal plan source spectrum over each frequency band, these levels are then corrected to SELs;

2) Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 8 Hz to 8 kHz, with a maximum range of 100 km and at 5-degree azimuth increments. The bathymetry variation along each modelling track is obtained via interpolation from the bathymetry 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;

4) The overall received SEL levels are calculated by summing all frequency band SEL levels.

3.2.2.2 Modelling scenarios

One long range modelling scenario is modelled for the 720 CUI source array. The source location (L1) as in **Table 3** and shown in **Figure 6** is selected for the long range modelling. The in-line survey directions are assumed as a North-South direction.

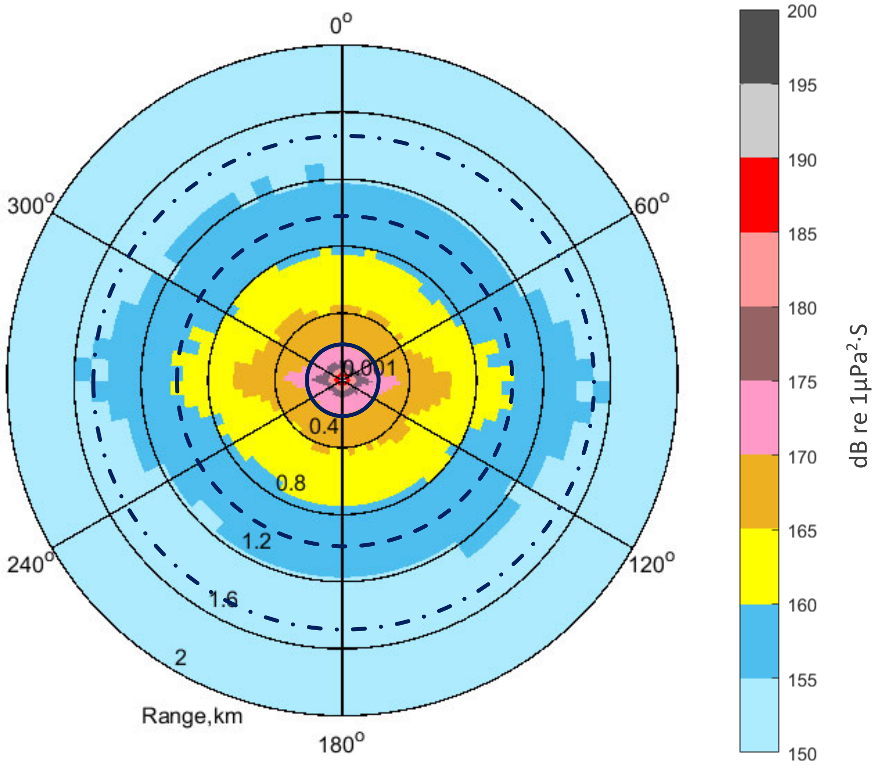
4 Modelling Results

This section presents the modelling results for the proposed seismic survey which include the short range and long range modelling results.

4.1 Seismic short range modelling

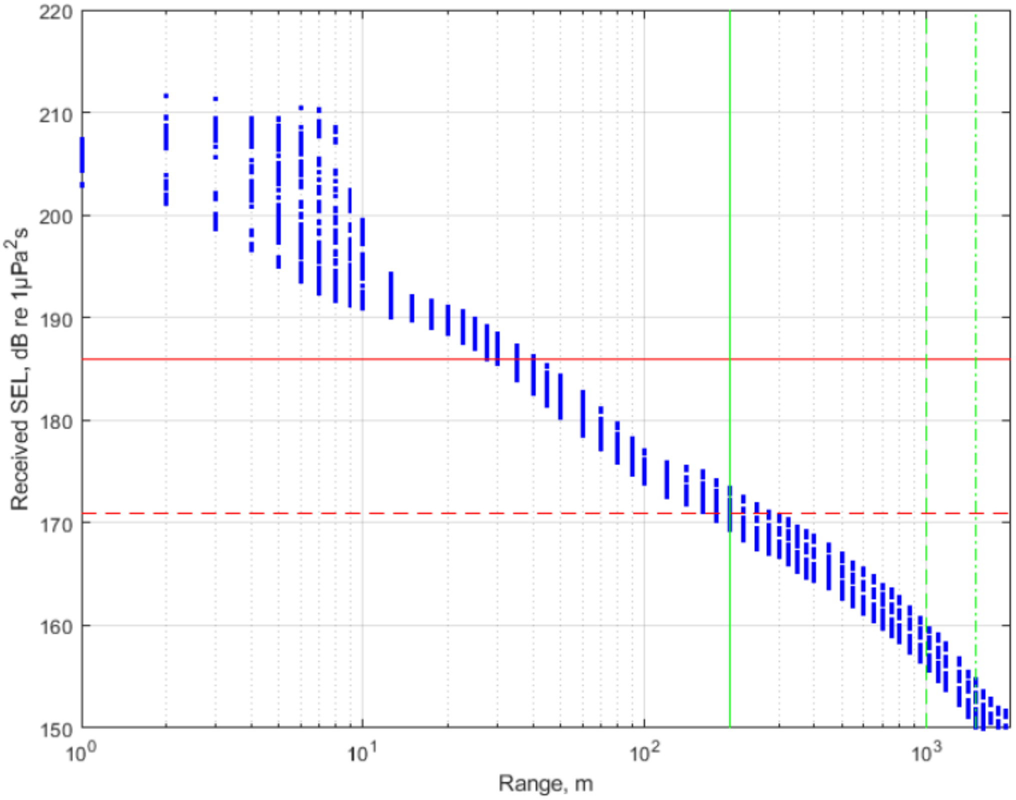
The received SEL levels have been calculated for the 720 CUI array at the source location S1. The modelling scenario is with the worst-case winter season sound speed profile and fine sand seabed sediment. The maximum received SELs across the water column are presented as a function of azimuth and range from the centre of the array in **Figure 12**. The figure illustrates higher SEL levels in both the in-line and cross-line directions as a result of the directionality of the source array.

Figure 12 The predicted maximum SELs across the water column as a function of azimuth and horizontal range from the centre of the array. 0 degree azimuth corresponds to the in-line direction. The modelling scenario is for the 720 CUI source array with a water depth of 20 m. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).



The scatter plot of the predicted maximum SELs across the water column from the source array for all azimuths are displayed in **Figure 13**, as a function of range from the centre of the source array, together with the mitigation threshold levels (i.e. 186 dB and 171dB re 1μPa²·S) and mitigation ranges (i.e. 200m, 1.0km and 1.5km).

Figure 13 Predicted SELs across the water column for all azimuths as a function of range from the centre of the source array for the 720 CUI array at source location S1. Horizontal red lines show mitigation thresholds of 186 dB re 1µPa2·S (solid) and 171dB re 1µPa2·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).



As can be seen from the figure, the maximum received SEL levels 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 SEL levels received at three mitigation ranges are listed in **Table 4**. **Table 5** presents the ranges from the centre of the source array to the ranges where the predicted maximum SEL levels are expected to equal the threshold levels (186 dB and 171 dB re 1µPa^2·s).

Table 4 Predicted maximum SEL for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the array for the 720 CUI array at source location L1.

Source location	Water depth, m	Seafloor	SEL at different ranges, dB re 1µPa²·s		
			200 m	1.0 km	1.5 km
L1	20	Fine sand	173	160	155

Table 5 Ranges from the centre of the array where the predicted maximum SEL for all azimuths equals the SEL threshold levels for the 720 CUI array at source location L1.

Source location	Water depth, m	Seafloor	Ranges complying with the following SEL thresholds, m	
			SEL < 186 dB re 1µPa²·s	SEL < 171 dB re 1µPa²·s
L1	20	Fine sand	45	275

4.2 Seismic long range modelling

Figure 14 shows the contour images of the predicted maximum SELs received at locations up to 100 km from the source location L1 overlaying the local bathymetry contours. The figure also illustrates that the shoreline is reached within 6 km to the south and 8 km to the east.

As can be seen from the contour figure, the received noise levels at far-field locations vary at different angles and distances from the source location. This directionality 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 14 Modelled maximum SEL (maximum level across water column) contours for source location L1 to a maximum range of 100 km, overlayed with bathymetry contour lines. Survey area outlined in blue, red polygon represents the West Coast North Island marine mammal sanctuary. Coordinates in WGS 84/Mercator 41.

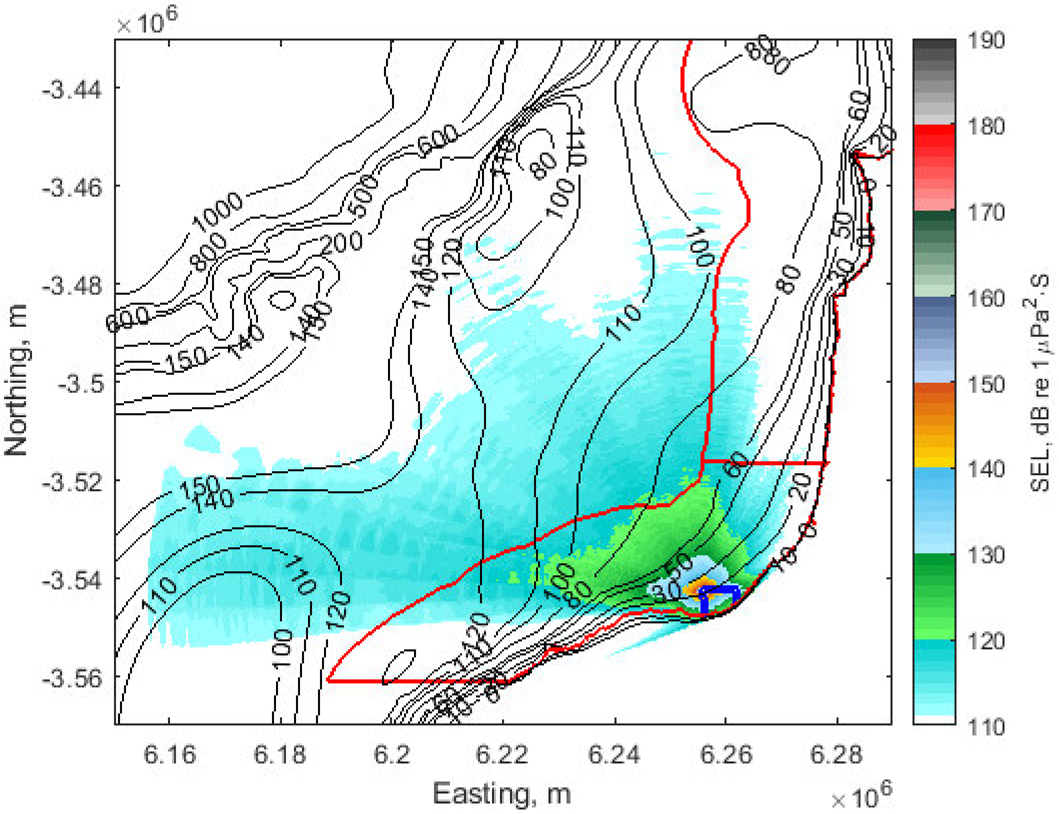


Figure 15 shows the noise propagation for the source location to the west, east, north and south directions. **Figure 16** shows the propagation in the direction from the source to the northwest with the greatest depth variation. This path is at a N 320° bearing. The maximum depth within the 100 km modelling distance is approximately 530 m.

As can be seen from the figures, from the source location towards the adjacent shoreline directions, sound energy has strong interaction with upslope seabed which consequently induces strong attenuation. The received SELs are predicted to be as low as 130 dB re 1µPa^2·s 5 km away from the array source location.

From the source location towards offshore directions along continental shelf regions, the sound energy initially interacts with downslope seabed. When the seabed is above approximately 100 m, the sound energy is predominantly trapped within the surface sound duct with limited interaction with the surface and the seabed, and as a result has less energy loss from rough surface scattering and seafloor absorption. At cross-line directions to the north and the east, the received SELs are predicted to be up to 110 dB re 1µPa^2·s 100 km away from the array source location.

Figure 15 Modelled SELs vs range and depth along the propagation path towards a) west b) east c) north and d) south direction from the source location L1. The black line shows the seabed depth.

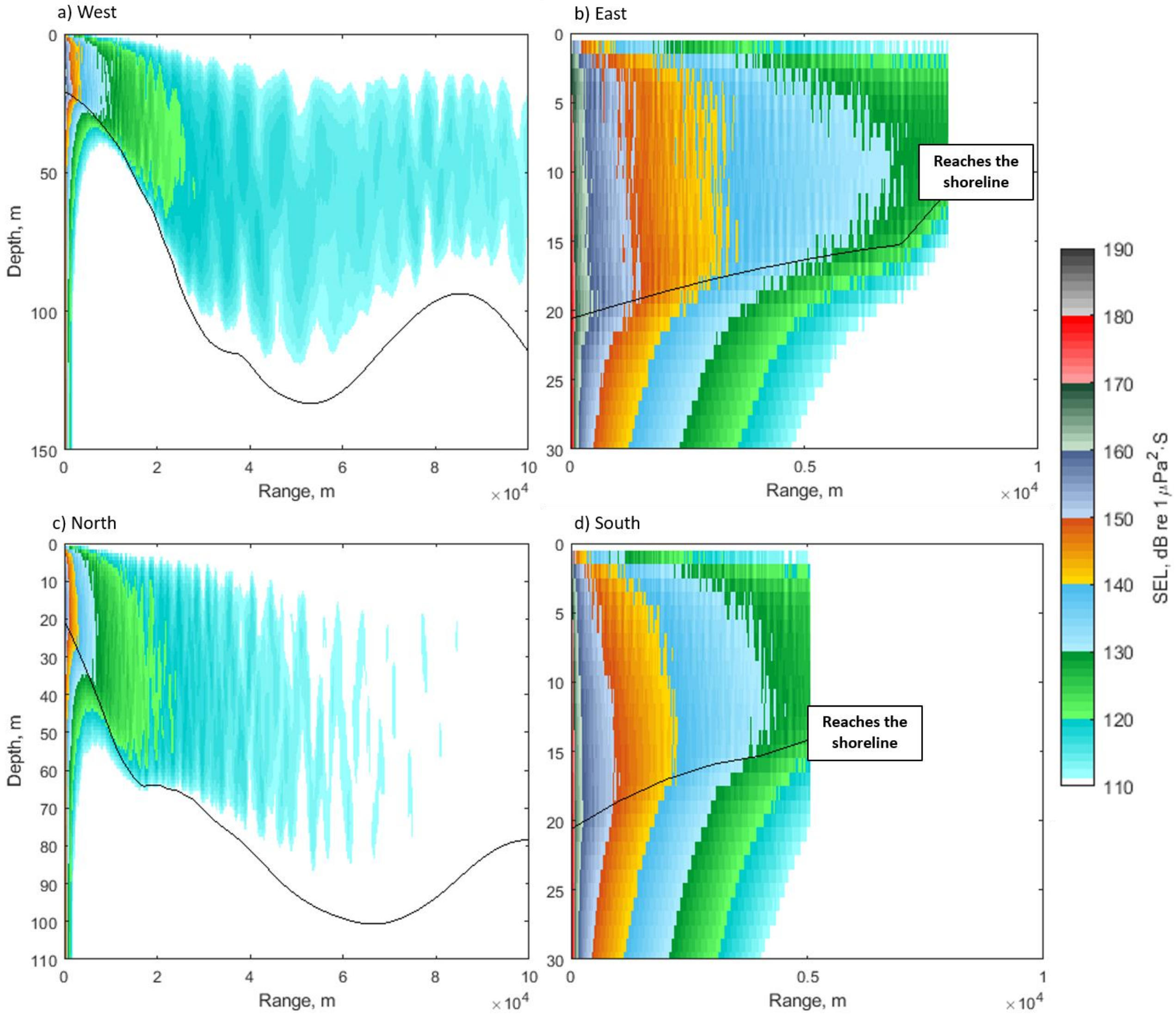
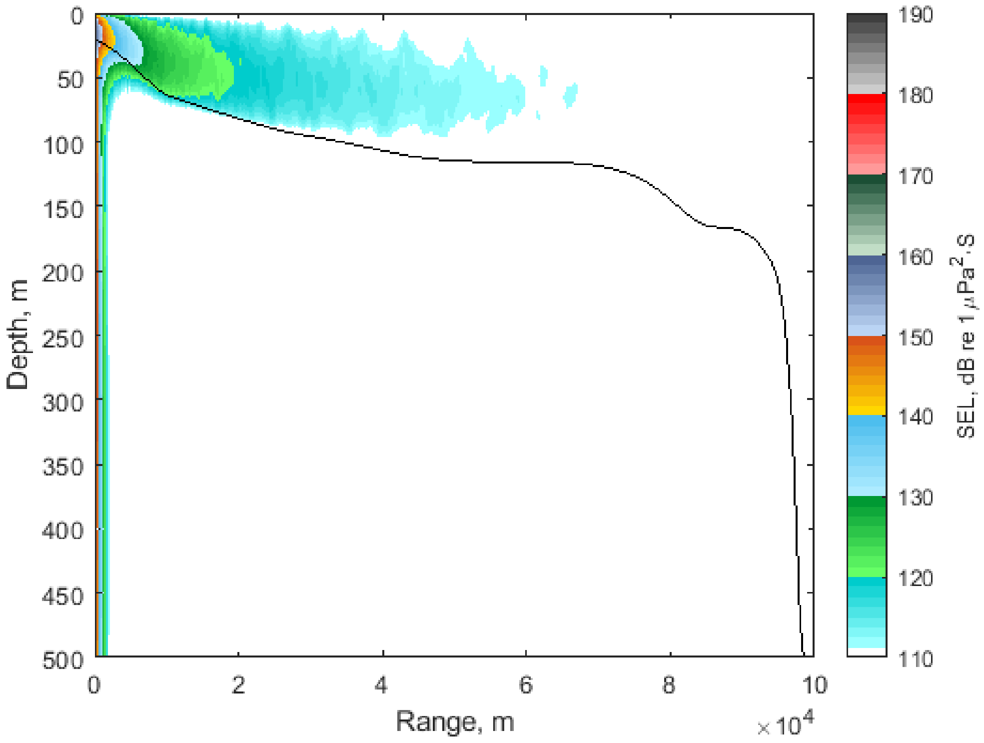


Figure 16 Modelled SELs vs range and depth along the propagation path from the source to the northwest direction



5 Conclusions

NZSL has proposed to undertake a 3D seismic survey within the North Taranaki Bight. This report details the sound transmission loss modelling study that has been carried out for the proposed survey, which includes three modelling components, e.g. array source modelling, short range modelling and long range modelling. The detailed modelling methodologies and procedures for the three components are described in **Section 2.2** and **Section 3.2** of the report.

The proposed acoustic source for this survey is a 720 CUI array. The location with the deepest water depth (approximately 20m) within the survey area was selected for the short and long range modelling. The worst case environmental conditions, i.e. winter season sound speed profile and fine sand seabed sediment, have been assumed for the modelling cases.

The short range modelling prediction demonstrates that the highest SELs occur in the in-line and cross-line directions, as a result of the directivity of the source array. The maximum received SEL levels 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 long range modelling shows that the received noise levels at long range vary significantly at different angles and distances from the source. This directionality 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. From the source location towards the adjacent shallower water shoreline directions, sound energy has strong interaction with the upslope seabed which consequently induces strong attenuation. The received SELs are predicted to be as low as 130 dB re 1μPa^2·s 5 km away from the array source location. To the offshore directions along continental shelf regions, the sound energy initially interacts with downslope seabed, and then is predominantly trapped within the surface sound duct with the depth increases, and as a result has limited energy loss due to less interaction with the sea surface and the seabed. At cross-line directions to the north and the east, the received SELs are predicted to be up to 110 dB re 1μPa^2·s 100 km away from the array source location.

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APPENDIX A

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 the 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 the pulse duration. The root-mean-square sound pressure level is the logarithmic ratio of the root of the mean-square pressure to the reference pressure. Pulse duration is taken as the duration between the 5% and the 95% points on the cumulative energy curve
Peak Sound Pressure Level (Peak SPL)	The peak sound pressure level is the logarithmic ratio of the peak pressure over the impulsive signal event to the reference pressure
Peak-to-Peak Sound Pressure Level (Peak-Peak SPL)	The peak-to-peak sound pressure level is the logarithmic ratio of the difference between the maximum and minimum pressure over the impulsive signal event to 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

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APPENDIX B

PAM Specifications

Specifications of the PAM equipment

Hardware

Blue Planet Marine can provide various customised passive acoustic monitoring systems suitable for detecting and monitoring cetaceans during seismic survey.

The towed hydrophone streamers are based on a well-established design by *Marine Ecological Research* in the United Kingdom. This design, which is a modern iteration of systems originally developed on a pioneering project funded by Shell UK to develop PAM for mitigation in the mid-1990s, has proven highly robust and reliable. It provides flexibility allowing the inclusion of various combinations of hydrophones and other sensors and can, if necessary, be disassembled and repaired in the field. Seismic PAM hydrophones operate in an environment in which the risk of hydrophone loss or damage is significant and options for external assistance are limited. While spare equipment is always provided, the use of a system that can be repaired in the field is, a distinct advantage. The systems that BPM would use for the survey will have a 340 m tow cable and an 80 m deck cable.

The variety of cetacean species likely to be encountered during seismic survey mitigation produce vocalisations over an extremely broad frequency range, from the infrasonic 15-30Hz calls of large baleen whales to the 130kHz pulses of harbour porpoise and Hectors dolphin. To be able to capture all of these, without being compromised by unwanted noise the PAM system uses two different hydrophone/preamp pairs with different but overlapping frequency sensitivity: a low/medium frequency pair and a high frequency pair. These hydrophone pairs can be monitored, filtered and sampled independently. The high frequency hydrophones are fed through two different processing chains so that its typical to process and monitor 6 (3 pairs) acoustic channels (Figure 1).

Higher frequency filtering and amplification hardware is custom-built by *Magrec* to meet the specification required for cetacean monitoring. Important features include adjustable low frequency filters from 0Hz to 3.2kHzs which can be applied to reduce low frequency noise allowing the available dynamic range to be conserved for capturing relevant marine mammal vocalisations within the frequency bands used each species. The Magrec HP27 preamp also provides an output with a fixed 20kHz low cut filter to optimise detection of the very high frequency vocalisations of porpoise, Hector’s dolphins, beaked whales and Kogia.

(The HP27 also provides clean power for the hydrophone preamplifiers within the streamer and houses a depth sensor reader.)

Audio and low-ultrasonic frequency bands (up to 96 kHz) can be filtered and amplified as necessary using a high quality Behringer preamplifier. Ultra-high frequency click detection (which is particularly useful for porpoise, Hector’s dolphins, Kogia etc.) is achieved by using a National Instruments Digital Acquisition card with a sampling rate of 1.2 mega samples s^{-1}. Other audio channels are captured at a sampling rate of 192kHz using a high-quality USB sound card.

Systems like this have been used from a wide variety of platforms ranging from sailing yachts to ocean-going research vessels, in waters from the tropics to the Antarctic. However, the need to monitor acoustically for mitigation has been a driver for much of the system’s development. Seismic survey mitigation monitoring has been conducted from guard vessels and from the main seismic survey vessel itself.

Software

The system is optimised for use with PAMGUARD. A software suite specifically designed for detecting, classifying and localising a wide variety of marine mammals during seismic surveys. Much of the funding for the development **of this program** came from the oil exploration industry. **MER** was part of the team that initiated the PAMGUARD project and remains closely associated with its development. The hardware described here, has been developed in parallel with the PAMGUARD software.

PAMGUARD is an extremely flexible program with a range of modules that can be combined to provide customised configurations to suit particular applications. It includes modules for detecting both transient vocalisations (clicks) and tonal calls (e.g. whistles and moans). Cetacean click vocalisations range from the medium frequency clicks of sperm whales that can be detected at ranges of several miles, through the powerful broadband clicks produced by most delphinids to the specialised narrow band pulses of beaked whales, harbour porpoises and Hector's dolphins. High frequency tonal sounds include the whistle vocalisations produced by delphinids while low frequency tonals are produced by baleen whales. When data from two or more hydrophone elements are available PAMGUARD can calculate bearings to these vocalizations and provide locations by target motion analysis **(e.g** Figure 2**)**.

PAMGUARD also includes routines for measuring and removing background noise, and for vetoing particularly intense sounds such as Airgun pules **which are essential when monitoring is required during seismic survey operation**.

In addition**,** PAMGUARD collects data directly from certain instruments. For example, it measures and displays the depth of the hydrophone streamer and takes NMEA data (such as GPS locations) from either the ship's NMEA data line or from the stand-alone GPS units provided with the equipment.

The ship's track, hydrophone locations, mitigation zones, airgun locations and locational information for acoustic detections are all plotted on a real-time map.

Species Detection

The frequency range, call type and vocal behaviour of cetaceans varies enormously between species and this affects the degree to which PAM provides additional detection capability, especially in the noisy environment of a seismic survey. This system has proven very effective in detecting small odontocetes and sperm whales, increasing detection reliability by an order of magnitude during trials (funded by Shell) conducted off the UK. PAM is particularly effective for the detection of sperm whales as they can be heard at significant ranges (several miles) and are consistently vocal for a large proportion of the time. Smaller odontocetes such as dolphins, killer whales, pilot whales and other "black fish" can be detected at useful ranges from both their whistle and click vocalisations but they often move so quickly that target motion may be difficult. The effective range for narrow band high frequency specialists, such as harbour porpoise is limited (usually to several hundred meters) by the high rate of absorption of their ultra-high frequency clicks. Detection range for these species is usually within proscribed mitigation ranges so that any reliable detection should lead to action. Towed hydrophones of this type have been very effective in picking up vocalisations from beaked whales during surveys and the narrow bandwidth and characteristic upsweep in their clicks greatly assists with their classification. However, beaked whales' clicks are highly directional and vocal output can be sparse and intermittent so overall detection probability may remain low.

The value of PAM in mitigating the effects of seismic operations with baleen whales has yet to be fully explored. These whales generally vocalise at low frequencies making them particularly vulnerable to masking and interference from vessel and flow noise. Further, although some baleen whale vocalisations are very powerful, they are less consistently vocal than most odontocetes. Many of their vocalisations appear to be breeding calls and may be produced seasonally and either solely or predominantly by males.

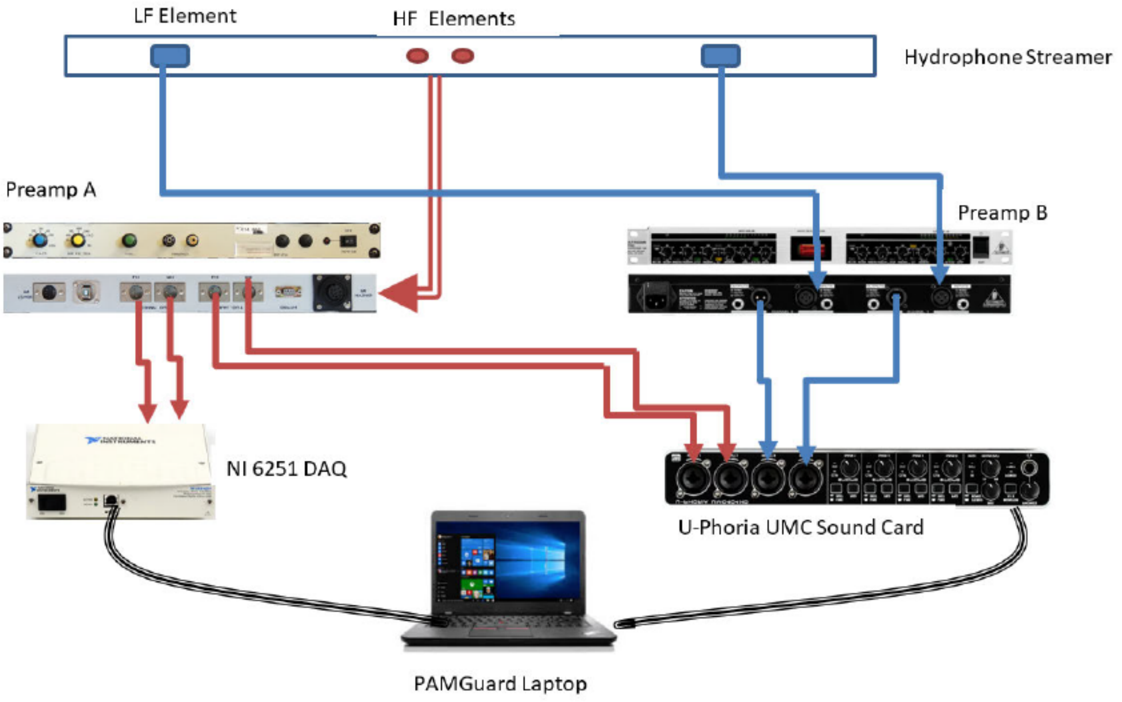
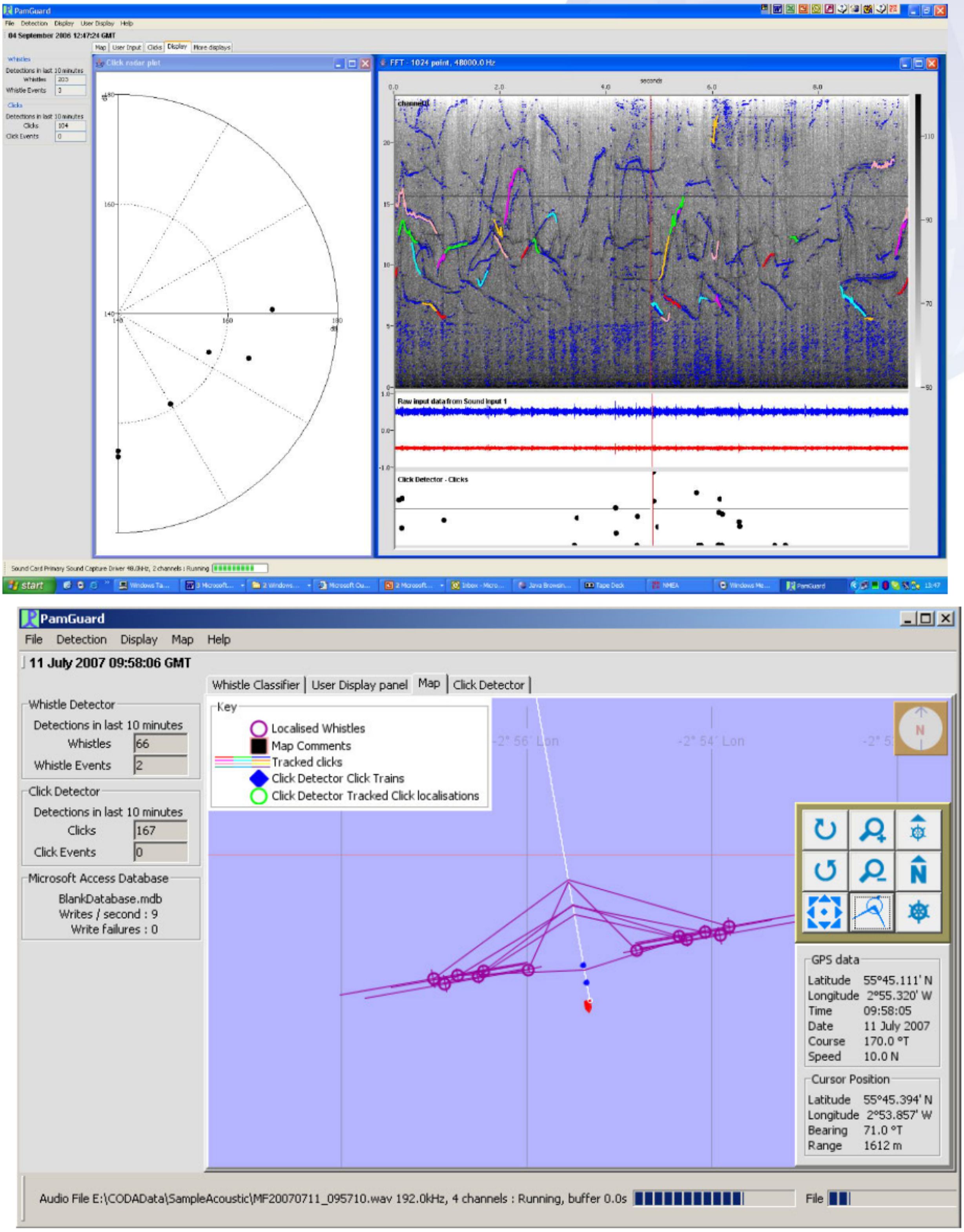


Figure 1 Schematic diagram showing the main elements of a typical six channel configuration of a Vanishing Point mitigation system.



04 September 2006 12:47:24 GMT

Whistles

Detections in last 10 minutes

Whistles 203

Whistle Events 3

Clicks

Detections in last 10 minutes

Clicks 104

Click Events 0

Sound Card Primary Sound Capture Driver 48.0kHz, 2 channels : Running

11 July 2007 09:58:06 GMT

Whistle Detector

Detections in last 10 minutes

Whistles 66

Whistle Events 2

Click Detector

Detections in last 10 minutes

Clicks 167

Click Events 0

Microsoft Access Database

BlankDatabase.mdb

Writes / second : 9

Write failures : 0

GPS data

Latitude 55°45.111' N

Longitude 2°55.320' W

Time 09:58:05

Date 11 July 2007

Course 170.0 °T

Speed 10.0 N

Cursor Position

Latitude 55°45.394' N

Longitude 2°53.857' W

Bearing 71.0 °T

Range 1612 m

Audio File E:\CODAData\SampleAcoustic\MF20070711_095710.wav 192.0kHz, 4 channels : Running, buffer 0.0s

File

Figure 2 Screen shot from PAMGUARD Whistle and Click Detection and Mapping and Localisation Modules typical of a Seismic Mitigation configuration

Standard Seismic Mitigation Acoustic Monitoring System	
Towed Hydrophone	
Acoustic Channels	2 x Medium Frequency Benthos AQ4. –201 dBV re 1µPa (+/- 1.5 dB 1-15kHz) with Magrec HP02 broad band preamps (LF cut filter @ 100Hz or 50Hz as required) Near-flat sensitivity 50Hz- 15kHz with good sensitivity to higher frequencies
	2 x High Frequency Magrec HP03 units, comprising a spherical ceramic and HP02 preamp (low cut filter set at 2kHz) Near flat sensitivity 2kHz- 150kHz. +/-6 dB 500Hz to 180kHz
Depth Sensor	Keller 4-20mA 100m range Automatically read and displayed within PAMUARD
Streamlined housing	5m, 3 cm diameter polyurethane tube. Filled with Isopar M.
Cable	340m multiple screened twisted pair lines and power, with strain relief and Kellum's grip towing eye, Length deployed may vary to suit application
Connectors	19 pin Ceep IP68 waterproof
Deck cable	~75m 19pin Ceep to breakout box
Topside Amplifier Filter Unit	
Unit	**Magrec HP/27ST**
Supply Voltage	10-35 V DC
Supply current	200mA at 12 V
Input	Balanced input
Gain	Adjustable: 0,10,20,30,40,50 dB
High Pass Filter	-6db/octave selectable: 0, 40, 80, 400,1.6k, 3.2k
Output	2 X Balanced output via 3 pin XLR
Ultra HF Output	2 X Balanced output via 3 pin XLR (with 20kHz high pass filter for porpoise detection)
Headphone	Two outputs via ¼" jack
Overall Bandwidth	10Hz-200kHz +/–3dB
Unit	**Behringer Mic 2200**
Supply Voltage	220v AC
Input	Balanced
Gain	10- 60dB
High Pass Filter	0-20kHz
Overall Bandwidth	Frequency response 10 Hz to 200 kHz, +/- 3 dB
Headphone	Monitored via independent headphone amp.
GPS	
Input	Serial to USB adapter to interface with ship's NMEA supply
Backup	Standalone USB unit provided as independent backup
Computers	
	Up to date Laptop Computers
Digitisers	
Digitiser	NI USB 6251 high speed Digital Acquisition
Sound Card	High quality sound card 192kHz sampling rate e.g. Beghringer UMC 404HD or RME Fireface 400
Software	

General	PAMGUARD with appropriate configurations

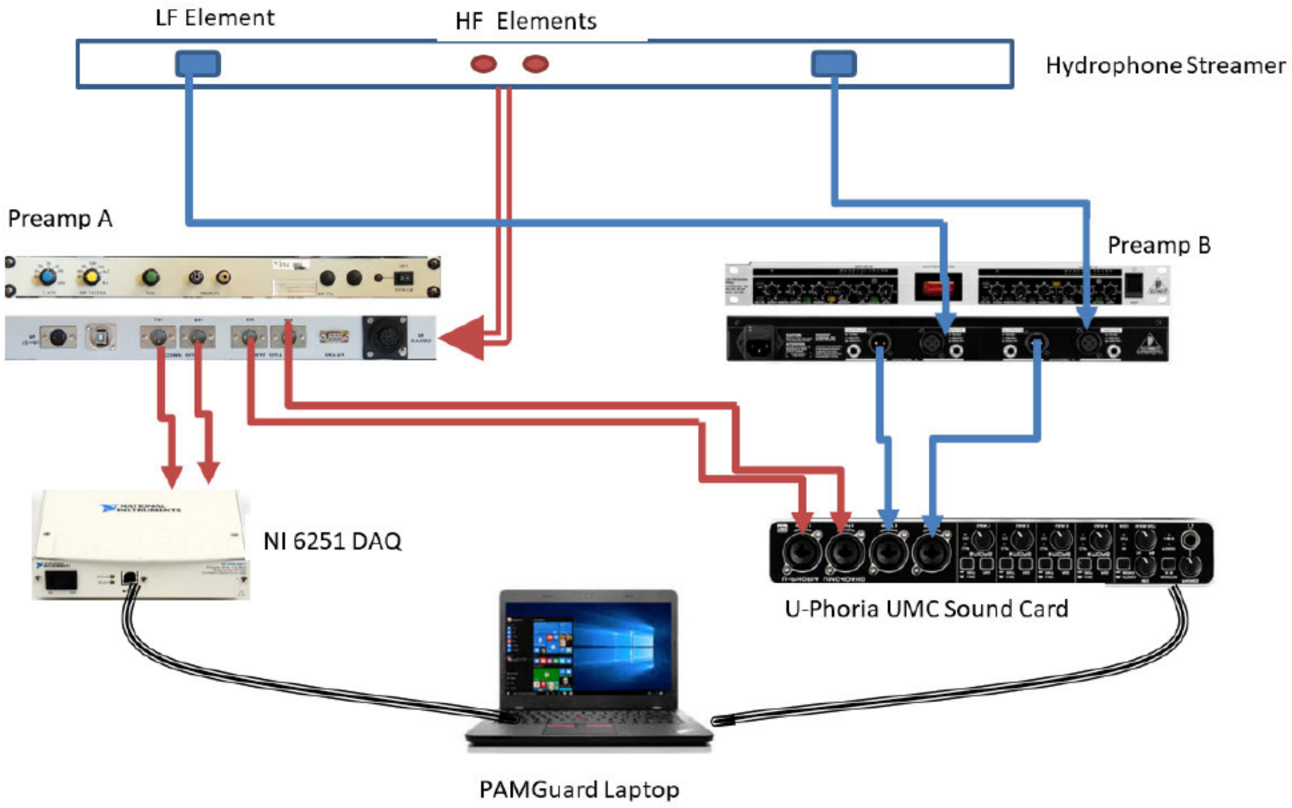


Figure 3 Schematic representation of BPM Multi-Channel PAM system

APPENDIX C

Code of Conduct Species of Concern

LATIN NAME	COMMON NAME
Megaptera novaengliae	Humpback Whale
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Whale
Balaenoptera bonaerensis	Antarctic Minke Whale
Balaenoptera acutorostrata subsp.	Dwarf Minke Whale
Balaenoptera musculus	Blue Whale
Balaenoptera physalus	Fin Whale
Balaenoptera musculus brevicauda	Pygmy Blue Whale
Eubalaena australis	Southern Right Whale
Caperea marginata	Pygmy Right Whale
Lissodelphis peronii	Southern Right-whale Dolphin
Globicephala melas	Long-finned Pilot Whale
Globicephala macrorhynchus	Short-finned Pilot Whale
Peponcephala electra	Melon-headed Whale
Physeter macrocephalus	Sperm Whale
Kogia sima	Dwarf Sperm Whale
Kogia breviceps	Pygmy Sperm Whale
Mesoplodon grayi	Gray's Beaked Whale
Berardius arnuxii	Arnoux's Beaked Whale
Ziphius cavirostris	Cuvier's Beaked Whale
Mesoplodon layardii	Strap-toothed Whale
Hyperoodon planifrons	Southern Bottlenose Whale
Mesoplodon bowdoini	Andrew's Beaked Whale
Mesoplodon mirus	True's Beaked Whale
Mesoplodon densirostris	Blainville's Beaked Whale
Mesoplodon gingkodens	Ginkgo-toothed Whale
Mesoplodon hectori	Hector's Beaked Whale
Mesoplodon peruvianus	Pygmy/Peruvian Beaked Whale
Tasmacetus shepherdi	Shepherd's Beaked Whale
Orcinus orca	Killer Whale
Pseudorca crassidens	False Killer Whale
Feresa attenuata	Pygmy Killer Whale
Cephalorhynchus hectori	Hector's Dolphin
Cephalorhynchus hectori maui	Maui's Dolphin
Phocarctos hookeri	New Zealand Sea Lion
Tursops truncatus	Bottlenose Dolphin

APPENDIX D

Proposed Coastal Plan for Taranaki Significant Indigenous Biodiversity and Taonga Species

Relevant Schedule 4A Threatened, At Risk, and Regionally Distinctive Species						
Common Name	Scientific Name	Regionally Distinctive	Found			
			Estuary (CMA or Land)	Intertidal (CMA)	Coastal bioclimatic zone (above CMA)	Marine (CMA)
Birds						
Antarctic prion	*Pachyptila desolata*					✓
Antipodean wandering albatross	*Diomedea antipodensis antipodensis*					✓
Australasian bittern	*Botaurus poiciloptilus*	✓	CMA, Land		✓	
Banded dotterel	*Charadrius bicinctus bicinctus*	✓	CMA, Land	✓	✓	
Banded rail	*Gallirallus philippensis assimilis*	✓	CMA, Land			
Black petrel	*Procellaria parkinsoni*					✓
Black shag	*Phalacrocorax carbo novaehollandiae*		CMA, Land		✓	
Black-fronted tern	*Chlidonias albostriatus*	✓	CMA, Land	✓	✓	✓
Broad-billed prion	*Pachyptila vittata*					✓
Buller’s shearwater	*Puffinus bulleri*					✓
Caspian tern	*Hydroprogne caspia*	✓	CMA, Land	✓	✓	✓
Eastern bar-tailed godwit	*Limosa lapponica baueri*		CMA, Land	✓	✓	
Fairy prion	*Pachyptila turtur*					✓
Far-eastern curlew	*Numenius madagascariensis*		CMA, Land	✓		
Flesh-footed shearwater	*Puffinus carneipes*					✓
Fluttering shearwater	*Puffinus gavia*				✓	✓
Grey-faced petrel	*Pterodroma macroptera gouldi*	✓			✓	✓
Grey-headed mollymawk	*Thalassarche chrysostoma*					✓
Hutton’s shearwater	*Puffinus huttoni*					✓
Lesser knot	*Calidris canutus rogersi*		CMA, Land	✓	✓	

Relevant Schedule 4A Threatened, At Risk, and Regionally Distinctive Species						
Little black shag	*Phalacrocorax sulcirostris*		CMA, Land		✓	
New Zealand pipit	*Anthus novaeseelandiae novaeseelandiae*		CMA, Land		✓	
New Zealand white-faced storm petrel	*Pelagodroma marina maoriana*					✓
North Island fernbird	*Bowdleria punctata vealeae*	✓	Land			
Northern blue penguin	*Eudyptula minor iredalei*		CMA, Land	✓	✓	✓
Northern diving petrel	*Pelecanoides urinatrix urinatrix*				✓	✓
Northern giant petrel	*Macronectes halli*					✓✓
Northern New Zealand dotterel	*Charadrius obscurus aquilonius*	✓	CMA, Land	✓	✓	
Northern royal albatross	*Diomedea sanfordi*					✓
Pied shag	*Phalacrocorax varius varius*		CMA, Land	✓	✓	
Pied stilt	*Himantopus himantopus leucocephalus*		CMA, Land	✓	✓	
Red-billed gull	*Larus novaehollandiae scopulinus*		CMA, Land	✓	✓	✓
Reef heron	*Egretta sacra sacra*	✓	CMA, Land	✓	✓	
Royal spoonbill	*Platalea regia*	✓	CMA, Land	✓	✓	
Salvin's albatross	*Thalassarche salvini*					✓
Sooty shearwater	*Puffinus griseus*				✓	✓
Sooty tern	*Onychoprion fuscata serratus*			✓		
South Island pied oystercatcher	*Haematopus finschi*		CMA, Land	✓	✓	
Spotless crake	*Porzana tabuensis tabuensis*	✓	CMA, Land			
Variable oystercatcher	*Haematopus unicolor*	✓	CMA, Land	✓	✓	
Westland petrel	*Procellaria westlandica*					✓
White heron	*Ardea modesta*	✓	CMA, Land			
White-capped albatross	*Thalassarche cauta steadi*					✓
White-chinned petrel	*Procellaria aequinoctialis*					✓
Wrybill	*Anarhynchus frontalis*	✓	CMA, Land	✓	✓	
Marine Mammals						
Bryde's whale	*Balaenoptera brydei/ B. edeni*					✓

Relevant Schedule 4A Threatened, At Risk, and Regionally Distinctive Species						
Common bottlenose dolphin	*Tursiops trucatus*					✓
False killer whale	*Pseudorca crassidens*					✓
Fin whale	*Balaenoptera physalus*					✓
Humpback whale	*Megaptera novaeangliae*	✓				✓
Hector's dolphin	*Cephalorhynchus hectori hectori*	✓				✓
Killer whale	*Orcinus orca Type A*					✓
Leopard seal	*Hydrurga leptonyx*			✓	✓	✓
Māui dolphin	*Cephalorhynchus hectori maui*	✓				✓
New Zealand fur seal	*Arctocephalus forsteri*	✓		✓	✓	✓
Short-beaked common dolphin	*Delphinus delphis*	✓				✓
Southern right whale	*Eubalaena australis*					✓
Sperm whale	*Physeter macrocephalus*					✓
Pygmy blue whale	*Balaenoptera musculus brevicauda*	✓				✓
Marine Invertebrates						
Cushion star	*Eurygonias hyalacanthus*					✓
Hydrozoan	*Nemertesia elongata*					✓
Spider crab	*Leptomithrax tuberculatus mortenseni*					✓
Stony coral	*Madrepora oculata*					✓
Whelk	*Cominella quoyana griseicalx*					✓
Chimeras, sharks and rays						
Basking shark	*Cetorhinus maximus*					✓
Great white shark	*Carcharodon carcharias*					✓
Smalltooth sand tiger shark	*Odontaspis ferox*					✓

Note: Terrestrial and freshwater species have not been included within this table; however, all species of bird listed under Schedule 4 of the PCP has been included for completeness.

Schedule 4B – Significant Indigenous Biodiversity Areas
Sensitive Marine Benthic Habitats
(Beds of) large bivalve molluscs
Brachiopods
Bryozoans (thickets)
Calcareous tube worm (thickets)
Macro-algal (beds)
Sponge (gardens)
Rhodolith (maerl beds)
Chaetopteridae worm (fields)
Sea pens (field)
Stony coral (thickets)
Xenophyophores (sessile protozoan beds)

Schedule 5 – Coastal Taonga Species		
Māori Name	**Common Name**	**Scientific Name**
Tuna	Long finned eel	*Anguilla dieffenbachia*
Tuna	Short finned eel	*Anguilla australis*
	Australian long finned eel	*Anguilla rheinhartii*
Piharau	Lamprey	*Geotria australis*
Pūpū	Cat's eye snail	*Lunella smaragdus/Diloma sp.*
Kōtoretore, Kotore, humenga	Sea anemone	*Order Actiniaria*
Karengo	Nori	*Porphyra/Pyropia sp.*
Rori, rore	Sea cucumber	*Australostichopus mollis*

Schedule 5 – Coastal Taonga Species		
Rori (which includes ngutungutukaka)	Shield Shell/Seasnail	*Scutus breviculus*
Hihiwa	Yellowfoot paua	*Haliotis australis*
Paua	Blackfoot paua	*Haliotis iris*
Kutai/Kuku	Blue mussel	*Mytilus edulis*
Kutai/Kuku	Green lipped mussel	*Perna canaliculus*
Pipi/Kakahi	Pipi	*Paphies australis*
Tītiko/Karehu	Mud snail	*Amphibola crenata, Lunella smaragdus, Diloma sp.*
Kina	Sea urchin	*Evechinus chloroticus*
Kōura	Rock lobster/crayfish	*Jasus edwardsii*
Īnanga	Whitebait	*Family Galaxiidae*
Hāpuka	Groper	*Polyprion oxygeneios*
Kaeo	Sea tulip	*Pyura pachydermatina*
Kahawai	Sea trout	*Arripis trutta*
Kanae	Grey mullet	*Mugil cephalus*
Koeke	Common Shrimp	*Palaemon affinis*
Mararī	Butterfish	*Odax pullus*
Moki	Blue Moki	*Latridopsis ciliaris*
Paraki/Ngaore/Pōrohe	Common smelt	*Retropinna retropinna*
Pāra	Frostfish	*Lepidopus caudatus*
Pātiki mahoao	Black flounder	*Rhombosolea retiaria*
Pātiki rore	New Zealand Sole	*Peltorhamphus novaezeelandiae*
Pātiki tore	Lemon Sole	*Pelotretis flavilatus*
Pātiki totara	Yellowbelly flounder	*Rhombosolea leporina*
Pātiki	Sand flounder	*Rhombosolea plebeia*
Pātukituki / Rāwaru	Blue cod/Rock cod	*Parapercis colias*

Schedule 5 – Coastal Taonga Species		
Pioke, Tope, Mangō	School shark/rig	*Galeorhinus galeus*
Reperepe	Elephant fish	*Callorhynchus millii*
Wheke	Octopus	*Macroctopus maorum*
Koiro, ngoiro, totoke, hao, ngoio, ngoingoi, putu	Conger eel	*Conger verreauxi*
Kaunga	Hermit crab	*Pagurus novizealandiae*
Pāpaka parupatu	Mud crab	*Austrohelice crassa*
Pāpaka parupatu	Paddlecrab	*Ovalipes catharus*
Patangatanga, patangaroa, pekapeka	Starfish	*Class Asteroidea*
Purimu	Surfclam	*Dosinia anus, Paphies donacina, Spisula discors, Spisula murchisoni, Crassula aequilatera, Bassina yatei, or Dosinia subrosea*
Tuangi	Cockle	*Austrovenus stutchburyi*
Tuatua	Tuatua	*Paphies subtriangulata, Paphies donacina*
Waharoa	Horse mussel	*Atrina zelandica*
Karauria, ngakihi, tio, repe	New Zealand rock oyster	*Saccostrea glomerata*
Kuakua, pure, tipa, tipai, kopa	Scallop	*Pecten novaezelandiae*
All species of marine mammals but specifically:		
Tohorā	Beaked whales	*Family Ziphiidae*
	Melon-headed whale	*Peponocephala electra*
	Pygmy killer whale	*Feresa attenuata*
	False killer whale	*Pseudorca crassidens*
	Killer whale	*Orcinus orca*
	Long-finned pilot whale	*Globicephala melas*
	Short finned pilot whale	*Globicephala macrorhynchus*
Parāoa	Sperm whale	*Physeter macrocephalus*
	Pygmy sperm whale	*Kogia breviceps*

Schedule 5 – Coastal Taonga Species		
	Dwarf sperm whale	*Kogia sima*
	Common bottlenose dolphin	*Tursiops truncatus*
Aihe	Short-beaked common dolphin	*Delphinus delphis*
	Hector's dolphin (South Island Hectors dolphin and Māui dolphin)	*Cephalorhynchus hectori (Cephalorhynchus hectori hectori and Cephalorhynchus hectori maui)*
	Dusky dolphin	*Lagenorhynchus obscurus*
	Risso's dolphin	*Grampus griseus*
	Spotted dolphin	*Stenella attenuata*
	Striped dolphin	*Stenella coeruleoalba*
	Rough-toothed dolphin	*Steno bredanensis*
	Sothern right whale dolphin	*Lissodelphis peronii*
	Spectacled porpoise	*Phocoena dioptrica*

Note: Freshwater species have not been included within this table.

APPENDIX E

Marine Mammal Mitigation Plan

TURANGI 3D SEISMIC SURVEY

Marine Mammal Mitigation Plan
North Taranaki

Prepared for:

NZ Surveys 2020 Limited
Level 9
151 Queen Street
Auckland

SLR Ref: 740.30001.00100-R03
Version No: -v2.1
April 2022

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with NZ Surveys 2020 Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.30001.00100-R03-v2.1	8 April 2022	SLR Consulting Limited	Dan Govier	Dan Govier
740.30001.00100-R03-v2.0	16 March 2022	SLR Consulting Limited	Dan Govier	Dan Govier
740.30001.00100-R03-v1.0	21 January 2022	SLR Consulting Limited	Dan Govier	Dan Govier

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

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ABBREVIATIONS AND DEFINITIONS

Code of Conduct	2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations
DOC	Department of Conservation
MMIA	Marine Mammal Impact Assessment
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Mammal Observer
NM	Nautical Mile
NZSL	NZ Surveys 2020 Limited
PAM	Passive Acoustic Monitoring

1 Introduction

1.1 Purpose of the Marine Mammal Mitigation Plan

This Marine Mammal Mitigation Plan (**MMMP**) has been developed to outline the procedures that are to be implemented for the responsible operation of seismic activities around marine mammals during operation of the Turangi 3D Seismic Survey.

Two operational areas are proposed (see **Section 1.2**), one being the primary acquisition area along the coastline of Onaero, North Taranaki and the second being a 1 km x 1 km acoustic source testing area off New Plymouth. The two Operational Areas lie within the boundaries of the West Coast North Island Marine Mammal Sanctuary, therefore this MMMP takes into consideration any requirements under the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008. Following the Marine Mammals Protection (West Coast North Island Sanctuary) Amendment Notice 2020, restrictions on seismic surveying within the West Coast North Island Marine Mammal Sanctuary were streamlined so that compliance with the Department of Conservation (**DOC**) *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (**Code of Conduct**) is compulsory.

This MMMP will be used by observers and crew to guide operations in accordance with the Code of Conduct.

1.2 Survey Outline

NZ Surveys 2020 Limited (**NZSL**) plan to commence the Turangi 3D Seismic Survey within coastal waters of North Taranaki in March/April 2022. The Turangi 3D Seismic Survey is planned as a transitional seismic survey to fill a data gap between an existing marine 3D seismic survey and land-based 3D seismic data. This survey will utilise a boat-based acoustic source and an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system.

Two operational areas are proposed; one being the primary acquisition area along the coastline of Onaero, North Taranaki (labelled as 'Turangi 3D Operational Area' in **Figure 1**, and hereafter referred to as the **Primary Operational Area**), and the second being a 1 km x 1 km acoustic source testing area off New Plymouth (labelled as 'Turangi 3D Testing Area' in **Figure 1**, and hereafter referred to as the **Testing Area**). The acoustic source will only be operated within these two defined areas.

Table 1 Approximate Operational Area Coordinates

Operational Area	New Zealand Transverse Mercator		WGS84 Decimal Degrees	
	Easting (m)	Northing (m)	Latitude	Longitude
Primary Operational Area	1723233	5688265	174.42203649	-38.94589670
	1717425	5688252	174.35503572	-38.94681102
	1715666	5685884	174.33514308	-38.96837812
	1715706	5683555	174.33599897	-38.98935465
	1723312	5685764	174.42339858	-38.96841620
Testing Area	1691347	5678473	174.05546872	-39.03802370
	1692347	5678473	174.06702134	-39.03791859
	1692347	5677473	174.06715689	-39.04692832
	1691347	5677473	174.05560280	-39.04703346

During the seismic survey the acoustic source will be lowered into the water column and towed behind a source vessel. The sound produced by the acoustic source will be received by an ocean bottom acquisition system, being either ocean bottom cables or an ocean bottom node system. If an ocean bottom node system is used it would consist of approximately 280 nodes covering an area of 9.95 km^2 of seabed. Additional nodes would be deployed where any infill is required along the coast. Nodes would be placed at 150 m station intervals, with a tether and weights attached to assist in retrieval following the completion of seismic acquisition.

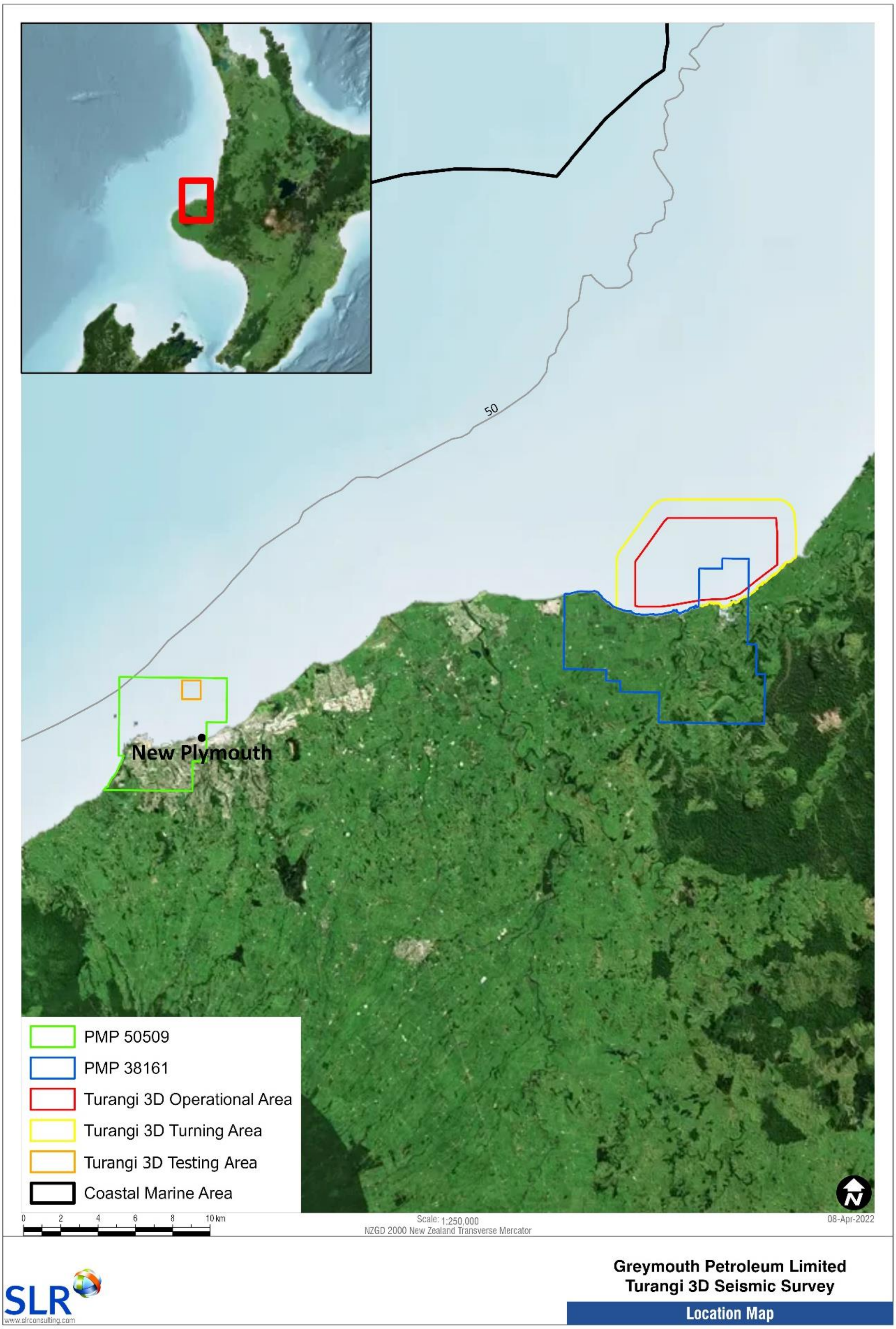
Retrieval of the ocean bottom acquisition system will commence at the conclusion of acquisition of all source points. The duration of the marine component of this survey is weather dependant around sea state but is anticipated to be approximately three weeks (21 days) from ocean bottom acquisition system deployment to retrieval. Acquisition will take approximately seven days and will only occur during daylight hours.

The two potential acoustic source array configurations and associated sound levels for the Turangi 3D Seismic Survey have been proposed to ensure sufficient power to fulfil the survey objective (1,420 in^3 and 1,000 in^3), whilst minimising excessive acoustic noise in the surrounding marine environment. A maximum source level of 1,420 in^3 is proposed by NZSL, and in accordance with the Code of Conduct, the Turangi 3D Seismic Survey is classified as a Level 1 seismic survey on account of the acoustic source being greater than 427 in^3.

Two vessels will be mobilised for the Turangi 3D Seismic Survey; a primary source vessel and a node/acoustic positioning vessel (termed the 'secondary vessel'). The acoustic source will be towed behind the primary source vessel, while nodal deployment and acoustic positional will be operated from the secondary vessel. The Marine Mammal Observers (**MMO**) and Passive Acoustic Monitoring (**PAM**) system and PAM Operators will be stationed onboard the primary source vessel.

The Turangi 3D Seismic Survey is scheduled to occur in March/April 2022.

Figure 1 Location of Operational Areas



2 Procedures for Seismic Operations

2.1 Standard Procedures

The procedures outlined below are stipulated by the Code of Conduct and largely represent the standard mitigations that operators must implement for compliance with the Code of Conduct during a Level 1 seismic survey. However, additional monitoring and mitigation requirements have been added by the Director-General of Conservation, due to the survey occurring in a marine mammal sanctuary, these are also included in the subsections below and are specifically identified by way of a footnote.

Section 2.2 describes the variations that are specific to the Turangi 3D Seismic Survey.

2.1.1 Notification

The notification requirements of the Code of Conduct have been adhered to. The Director General of Conservation at DOC was notified of NZSL’s intentions to carry out the Turangi 3D Seismic Survey.

2.1.2 Marine Mammal Impact Assessment

When operating within a Marine Mammal Sanctuary an Environmental Impact Assessment, also referred to as a Marine Mammal Impact Assessment (**MMIA**), is required to be submitted to the Director General of Conservation at the earliest opportunity but not less than three months before commencing the survey.

2.1.3 Observer Requirements

Level 1 seismic surveys require the use of MMOs in conjunction with PAM. The purpose of the MMOs is to 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 of the Code of Conduct.

The minimum qualified observer requirements for a Level 1 seismic survey are as follows:

- There will be at least two trained and qualified MMOs on-board at all times;
- There will be at least two trained and qualified PAM Operators on-board at all times;
- The roles of MMO and PAM Operator 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). A summary of the duties of the MMO and PAM Operator are presented in **Table 2**;
- At all times when the acoustic source is in the water, two[1] qualified MMOs 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 working day.

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[1] The requirement for two qualified MMOs on duty at all times when the acoustic source is in the water is a specific addition to manage potential effects in the marine mammal sanctuary.

The MMOs and PAM Operators must schedule their shifts and breaks in such a way as to manage their fatigue levels appropriately so focus on the required monitoring can be maintained.

Marine mammal observations by crew members are accommodated under the Code of Conduct through the following prescribed process:

1. Crew member to promptly report sighting to MMO;
2. If marine mammal remains visible, MMO to identify marine mammal and distance from acoustic source; and
3. If marine mammal is not observed by the MMO, the crew member will be asked to complete a sighting form and the implementation of any resulting mitigation action will be at the discretion of the MMO.

Table 2 Operational Duties of Qualified Observers

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 hydrophone arrays.
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticule 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 when there is a significant change in weather condition.	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, and the time and duration it was heard.
Implement appropriate mitigation actions (delayed starts and shut downs).	Implement appropriate mitigation actions (delayed starts and shut downs).
Record acoustic source power output while in operation, and any mitigation measure 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.

2.1.4 PAM Operations

As the detection range of current PAM technology is limited, any ultra-high frequency detections by PAM 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. In this situation it is not necessary to determine whether the detected marine mammal is within a mitigation zone; however, shutdown of an activated source will not be required if visual observations by an MMO confirm the acoustic detection was of a species falling into the category of 'Other Marine Mammals' (i.e. not a Species of Concern – see **Appendix 1**).

In the event that the PAM system malfunctions[2] or becomes damaged, seismic operations may continue for 20 minutes without PAM while the PAM Operator diagnoses the issue. If it is found that the PAM system needs to be repaired, seismic operations may continue for an additional two hours without operational 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.

2.1.5 Reporting Requirements

MMOs and PAM Operators are required under the Code of Conduct to record and report all marine mammal sightings during the survey, regardless of where they occur in relation to any mitigation zones. The following DOC standardised excel datasheets must be used for reporting purposes:

- On-survey Excel Reporting Form: http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/on-survey-seismic-mmo-reporting-form.xls
- Off-survey Excel Reporting Form: http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/off-survey-seismic-mmo-reporting-form.xls

All raw datasheets must be submitted directly to DOC at the earliest opportunity, but no longer than 14 days after the completion of the Turangi 3D Seismic Survey. DOC must also be provided with a written final report at the earliest opportunity, but no later than 60 days after the completion of the Turangi 3D Seismic Survey.

If qualified observers (i.e. MMOs 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. In the event that the Director-General of Conservation determines additional measures are necessary, the MMO/PAM team in conjunction with NZSL would then immediately implement any adaptive management actions without delay.

DOC must be immediately notified in the event of any incidents of non-compliance with the Code of Conduct.

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[2] PAM malfunction can relate to the towed PAM equipment, or the software used to receive, process and display acoustic detections.

2.1.6 Pre-start Observations

During the Turangi 3D Seismic Survey, the acoustic source can only be activated if it is within the specified Primary Operational Area or Testing Area (see **Figure 1**), and no night-time activation of the acoustic source shall occur[3].

As NZSL will only acquire during daylight hours, there will be a substantial (i.e. overnight) break in activation of the acoustic source. Although operations will continue the following day (if weather conditions allow) within the same location (i.e. within the Primary Operational Area), this break meets the requirement of a 'new location' for each day of the Turangi 3D Seismic Survey[4]. On this basis, the following additional start-up requirements will be applied to the first source activation of the day in poor sightings conditions:

- Two MMOs will have undertaken observations within 20 Nautical Miles (**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.

The following pre-start protocol will be adhered to for source activation in good or poor conditions (following standard Code of Conduct requirements):

- The acoustic source cannot be activated during daylight hours unless:
    - Two qualified MMOs have 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 (other than New Zealand fur seals) have been observed in the respective mitigation zones for at least 30 minutes, and no New Zealand fur seals have been observed in the relevant mitigation zones for at least 10 minutes; and
    - If PAM is incorporated into the survey plan, PAM for the presence of marine mammals has been carried out by a trained and 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.

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[3] The prohibition of night-time operations is a specific addition to manage potential effects in the marine mammal sanctuary

[4] The first activation of the source each day being treated as a 'new location' is a specific addition to manage potential effects in the marine mammal sanctuary

2.1.7 Soft Starts

Soft starts consist of gradually increasing the source's power, starting with the lowest capacity acoustic source, over a period of at least 20 minutes and no more than 40 minutes. With regard to soft starts, the following points are critical:

- The operational source capacity is not to be exceeded during the soft start period or during source testing; and
- The observer team must draw this to the attention of the seismic staff on-board the primary source vessel.

Where possible, initial activation of the acoustic source must be by soft start, unless the source is being reactivated after a break in firing less than 10 minutes before that time (not in response to a marine mammal observation within a mitigation zone).

2.1.8 Mitigation Zones for Delayed Starts and Shutdowns

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

If, during pre-start observations or while the acoustic source is active (including during soft starts), a qualified observer detects at least one Species of Concern with a calf within 1.5 km of the acoustic source, start-up procedures will be delayed, or the acoustic 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 acoustic source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1.5 km of the acoustic source, and the mitigation zone remains clear.

Where marine mammal detection occurs via PAM it shall be recognised that calves and adults cannot be differentiated, therefore calf presence must be assumed, and the 1.5 km mitigation zone will apply to all Species of Concern.

Species of Concern within a mitigation zone of 1 km

If during pre-start observations, or while the acoustic source is active (including during soft starts), a qualified observer detects a Species of Concern within 1 km of the source, start-up will be delayed, or the acoustic 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 km from the acoustic source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a Species of Concern within 1 km of the acoustic 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 acoustic source; or
- Despite continuous observation, 10 minutes has elapsed since the last detection of a New Zealand fur seal within 200 m of the acoustic 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 have moved beyond the respective mitigation zones, and the mitigation zone has remained clear for 30 minutes, there will be no further delays to the initiation of soft start procedures.

2.1.9 Acoustic Source Testing

Acoustic source testing will be subject to the relevant soft start procedure, although for testing, the 20-minute minimum duration does not apply. The power of the acoustic source should be built up gradually to the required test level at a rate not exceeding that of a normal soft start. The operational source capacity is not to be exceeded during source testing.

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

Acoustic source testing will only occur within the Testing Area as shown in **Figure 1**. The coordinates of this area are listed in **Table 1**.

2.1.10 Key Contacts and Communication Protocol

The key contact for DOC is Dave Lundquist who can be contacted by phone on +64 [redacted] or email at [redacted]@doc.govt.nz. Dave is the point of contact for all DOC enquiries or notifications except those outlined in **Section 2.2.1** (relating to advance notification of operational days and immediate notification of Māui's/Hector's dolphin sightings).

Note that NZSL must be kept informed of any correspondence with DOC; in this regard please copy all emails to [redacted] at NZSL. Any phone calls made to DOC should be followed up with an email to confirm the message; please cc these emails to [redacted] at [redacted]@nzsurveys2020.co.nz.

2.2 Additions to the Code of Conduct

The procedures outlined in this section are further to those required by the Code of Conduct. These additional procedures will be adopted by NZSL for the purpose of the Turangi 3D Seismic Survey. Based on this, it is imperative that these procedures are considered as strict requirements of the survey and therefore constitute additional responsibilities of qualified observers during the Turangi 3D Seismic Survey.

2.2.1 Reporting Requirements

In addition to the Code of Conduct reporting requirements outlined in **Section 2.1.5**, the following additional reporting components will be required:

- DOC Taranaki staff will be notified in advance of the days when the acoustic source is likely to be active to allow a fast response to any Māui's/Hector's dolphin sightings;
- MMOs to notify DOC immediately of any Hector's/Maui's dolphin sightings. These sightings will be made via telephone to Cameron Hunt on +64 [redacted] and email to [redacted]@doc.govt.nz, with a follow up email sent to [redacted]@doc.govt.nz.
- Marine mammal sightings will be collected whilst in transit to the Primary Operational Area or Testing Area. These records will be collated onto the DOC standardised 'Off-survey Excel Reporting Forms' (http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/off-survey-seismic-mmo-reporting-form.xls) and will be provided to DOC no later than 14 days after the completion of each deployment;
- MMOs will be vigilant for dead marine mammals observed at sea and will report details of any incidences to DOC in the final trip report; and
- Personnel onboard the survey vessels will at all times remain vigilant for sightings of little blue penguins. Observations of little blue penguins will be included in daily observations and reported alongside the required marine mammal observations.

2.2.2 Other

In the event that a marine mammal stranding event occurs inshore of the Primary Operational Area or Testing Area during the Turangi 3D Seismic Survey, or up to two weeks following the completion of the survey, NZSL will on a case-by-case basis consider covering the cost of a necropsy in an attempt to determine the cause of death. This will be considered following discussions with DOC. DOC would be responsible for all logistical aspects associated with the necropsy such as coordination with Massey University pathologists to undertake the work.

APPENDIX 1

Species of Concern

LATIN NAME	COMMON NAME
Megaptera novaengliae	Humpback Whale
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Whale
Balaenoptera bonaerensis	Antarctic Minke Whale
Balaenoptera acutorostrata subsp.	Dwarf Minke Whale
Balaenoptera musculus	Blue Whale
Balaenoptera physalus	Fin Whale
Balaenoptera musculus brevicauda	Pygmy Blue Whale
Eubalaena australis	Southern Right Whale
Caperea marginata	Pygmy Right Whale
Lissodelphis peronii	Southern Right-whale Dolphin
Globicephala melas	Long-finned Pilot Whale
Globicephala macrorhynchus	Short-finned Pilot Whale
Peponcephala electra	Melon-headed Whale
Physeter macrocephalus	Sperm Whale
Kogia sima	Dwarf Sperm Whale
Kogia breviceps	Pygmy Sperm Whale
Mesoplodon grayi	Gray's Beaked Whale
Berardius arnuxii	Arnoux's Beaked Whale
Ziphius cavirostris	Cuvier's Beaked Whale
Mesoplodon layardii	Strap-toothed Whale
Hyperoodon planifrons	Southern Bottlenose Whale
Mesoplodon bowdoini	Andrew's Beaked Whale
Mesoplodon mirus	True's Beaked Whale
Mesoplodon densirostris	Blainville's Beaked Whale
Mesoplodon gingkodens	Ginkgo-toothed Whale
Mesoplodon hectori	Hector's Beaked Whale
Mesoplodon peruvianus	Pygmy/Peruvian Beaked Whale
Tasmacetus shepherdi	Shepherd's Beaked Whale
Orcinus orca	Killer Whale
Pseudorca crassidens	False Killer Whale
Feresa attenuata	Pygmy Killer Whale
Cephalorhynchus hectori	Hector's Dolphin
Cephalorhynchus hectori maui	Maui's Dolphin
Phocarctos hookeri	New Zealand Sea Lion
Tursops truncatus	Bottlenose Dolphin

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