SLR

global environmental solutions

18SBB3D Seismic Survey

Marine Mammal Impact Assessment

Report Number 740.10079

7 February 2018

Todd Exploration Management Services Ltd

32-38 Molesworth Street

New Plymouth 4310

New Zealand

Version: v1.0

18SBB3D Seismic Survey

Marine Mammal Impact Assessment

PREPARED BY:

SLR Consulting NZ Limited
Company Number 2443058
5 Duncan Street
Port Nelson 7010, Nelson New Zealand
(PO Box 5061, Port Nelson 7043 Nelson New Zealand)
+64 274 898 628
nelson@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10079-R01-v1.0	29 January 2018	Helen McConnell, Nicole Pannell, Dan Govier	Dan Govier	Dan Govier
740.10079-R01-v0.3	25 January 2018	Helen McConnell, Nicole Pannell, Dan Govier	Dan Govier	Dan Govier
740.10079-R01-v0.2	12 January 2018	Helen McConnell, Nicole Pannell, Dan Govier	Dan Govier	Dan Govier
740.10079-R01-v0.1	27 December 2017	Helen McConnell, Nicole Pannell, Dan Govier	Dan Govier	Dan Govier

Executive Summary

Todd Exploration Management Services Limited (TEMS) is proposing to operate a three dimensional (3D) marine seismic survey in the South Taranaki Bight. While the actual area to be surveyed will only be about 320 km^2, the Operational Area required for the '18SBB3D Seismic Survey' encompasses an area of approximately 1,856 km^2 between Hawera and Whanganui. It straddles both the Exclusive Economic Zone (EEZ) (from 12 M out to 200 M) and the Coastal Marine Area (CMA) (from mean high water springs out to 12 M) and includes a region known as the 'Patea Shoals' (an area of the South Taranaki Bight offshore from Patea as depicted in LINZ Charts and Beaumont et al., 2013). The seismic survey is proposed to commence in February 2018 and last approximately 5 days.

A marine seismic survey in the EEZ is classified as a permitted activity under the *Exclusive Economic Zone & Continental Shelf (Environmental Effects) Act 2012* (EEZ Act) providing the operator complies with the Department of Conservation's (DOC) '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*' (Code of Conduct). For seismic operations in the CMA, Section 16 of the Resource Management Act 1991 states that proponents of activities "shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level". Despite technically being voluntary within the CMA, compliance with the Code of Conduct is sufficient to satisfy this RMA requirement.

The preparation of a Marine Mammal Impact Assessment (MMIA) is a requirement of the Code of Conduct in order to describe the proposed seismic operations, provide a description of the baseline environment, identify potential effects of the operations on the environment, and to specify any proposed mitigation measures. An Environmental Risk Assessment (ERA) process is utilised throughout this MMIA to assess the significance of any predicted effects on the biological, socio-economic and cultural environments of relevance to the Operational Area. Engagement with stakeholders was also undertaken by TEMS as a key part of survey preparations.

Potential marine mammal presence in the Operational Area was thoroughly assessed using marine mammal sighting and stranding data. This assessment indicated that dwarf minke whales, bottlenose dolphins, dusky dolphins, false killer whales, Gray's beaked whales, Cuvier's beaked whales, long-finned pilot whales, pygmy blue whales, sperm whales, pygmy sperm whales, common dolphins and New Zealand fur seals are the marine mammal species most likely to be present. A number of these species are classified as threatened under the New Zealand Threat Classification System and are considered to be 'nationally critical' (Bryde's whale, killer whale, and Maui's dolphin), 'nationally endangered' (bottlenose dolphin, and Hector's dolphin), or 'nationally vulnerable' (southern right whale). Furthermore, the greater South Taranaki Bight has been identified as an important feeding and potential nursery area for blue whales. It is recognised that acoustic disturbance from seismic surveys has the potential to impact marine mammals. The Code of Conduct was developed by DOC in order to minimise both behavioural and physiological effects associated with acoustic disturbance.

Operating in compliance with the Code of Conduct is the primary mitigation measure that will be employed during the 18SBB3D Seismic Survey, in particular: Marine Mammal Observers (MMO) will be present on the seismic survey vessel to detect marine mammals using both visual and acoustic techniques; seismic operations will be delayed if marine mammals are detected in close proximity to the acoustic source before start up; the power of the acoustic source will be gradually increased during a 'soft start' prior to any operations to ensure that any undetected marine mammals have an opportunity to leave the vicinity before full power is reached; and the acoustic source will be shut down if marine mammals enter the defined mitigation zones.

Executive Summary

The survey is defined as a 'Level 1' survey under the Code of Conduct given it will use a 5085 cu.in source and TEMS will comply with the mitigation measures stipulated within the Code of Conduct. Further to the paragraph above, the implementation of defined mitigation zones around the acoustic source, which MMOs will continuously scan to detect any marine mammals that may enter these zones, and if required, will implement an immediate shutdown of the acoustic source. In order to predict how far sound emitted from the seismic survey will travel underwater, Sound Transmission Loss Modelling was conducted during the development of this MMIA. The primary purpose of this modelling is to assess the validity of the standard mitigation zones specified in the Code of Conduct. The modelling results did not comply with the Sound Exposure Level thresholds for the standard mitigation zones at 1 km for parts of the 18SBB3D seismic survey; hence, a larger mitigation zone has been proposed for this particular survey to ensure compliance levels are met. In particular, a mitigation zone of 1.5 km will be adopted as a conservative measure for all 'Species of Concern' (with or without calves) throughout the Operational Area.

In addition to compliance with the Code of Conduct, TEMS have committed to the following management actions to avoid, remedy or mitigate potential adverse effects on ecological, socio-economic and cultural components of the environment during the proposed operations:

- The survey is intended to be time-limited to minimise sound emissions within the marine environment;
- Source modelling has been undertaken to ensure that the survey is using the lowest practical acoustic source volume while still ensuring the geological objectives of the survey can be fulfilled;
- A 1.5 km mitigation radius will be implemented for all species of concern (whether with or without calves present) to optimise the efficacy of mitigation measures;
- Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey;
- Marine mammal sightings will be collected whilst off-survey (e.g. during transit to and from the Operational Area to the local port etc.);
- MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea;
- MMOs will notify DOC immediately of any Hector's/Maui's dolphin sightings;
- A Weekly MMO report will be provided to the relevant agencies (i.e. DOC and the Environmental Protection Authority (EPA);
- TEMS will consider covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings in the vicinity of the Operational Area;
- Seismic operations will be undertaken in accordance with industry best practice, including compliance with international conventions relating to waste disposal, atmospheric emissions, oil pollution and biosecurity;
- Iwi Marine Mammal Operators (MMOs) and Passive Acoustic Monitoring (PAM) operators will be provided with employment opportunities during the survey; and
- Post-survey engagements will be conducted to inform iwi and stakeholders of key survey outcomes.

TEMS revised their initial Operational Area on account of the potential for encountering Maui's dolphins towards the more shallow coastal waters near Hawera. Although the initial likelihood of encountering this species was unlikely, the revision of that initial Operational Area provides a further mitigation measure against any potential behavioural impacts on Maui's dolphins.

Executive Summary

Based on the ERA results, the predicted effects of the 18SBB3D seismic survey are generally considered to be **negligible** to **moderate**, with moderate effects representing a short-term impact that is sufficiently managed by the proposed mitigation measures and the short duration of the survey.

Based on the potential for three consecutive surveys to be acquired in offshore Taranaki over the 2017/2018 summer seismic season there is a **moderate** risk of some cumulative effects on marine mammal behaviour and perception (i.e. masking) across the wider South Taranaki Bight The chance of cumulative effects would remain significant in the absence of this survey due to its short duration relative to the lengthy Western Platform 3D and the Maui 4D surveys. The planned 5 days for the 18SBB3D survey will have only a limited incremental effect. It is also worth bearing in mind that at distances beyond 100 km in the South Taranaki Bight the Sound Exposure Levels from this survey are likely to be about the same as, or marginally above, the ambient noise levels in the ocean.

TABLES

FIGURES

1 INTRODUCTION

1.1 Background

Todd Exploration Management Services Limited (TEMS) is proposing to operate a three dimensional (3D) marine seismic survey in the South Taranaki Bight[1]. The Operational Area is illustrated in **Figure** 1, and defines the maximum spatial extent of all proposed seismic operations (data acquisition, acoustic source testing, run-ins/outs and soft starts). While the area to be surveyed will only be about 320 km^2 and is expected to take about 5 days to survey, the Operational Area required for the 18SBB3D seismic survey will encompass a total area of approximately 1,856 km^2 offshore between Hawera and Whanganui over a region known as the ‘Patea Shoals’. The Operational Area straddles the boundary of the 12 nautical mile (M) Coastal Marine Area (CMA) (also known as the Territorial Sea); with approximately 50% occurring in the CMA and 50% occurring in the Exclusive Economic Zone (EEZ).

The proposed survey, known as the ‘18SBB3D seismic survey’, will occur over part of Petroleum Exploration Permit (PEP) 60094 as issued by New Zealand Petroleum and Minerals. The survey is planned to commence in February 2018. It is anticipated that the survey could take up to five days to complete. However, the absolute survey duration will be dependant on down-time for weather and marine mammal encounters. The proposed seismic operations will be conducted from the *MV Amazon Warrior*.

A marine seismic survey in the EEZ is classified as a permitted activity under the Exclusive Economic Zone & Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) providing the operator complies with the ‘2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations’ (Code of Conduct) (DOC, 2013). The Code of Conduct is summarised in **Section 3.5**.

For seismic operations in the CMA, the Taranaki Regional Coastal Plan also considers seismic surveying as a permitted activity if operators comply with the Code of Conduct. . The DOC marine mammal sighting database has been checked to ensure that no monther/calf sightings have been identified within the proposed Operational Area. In addition, Section 16 of the Resource Management Act 1991 (RMA) states that proponents of activities “shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level”. Compliance with the Code of Conduct and TEMS selecting a source level and array configuration that will provide sufficient power to fulful the geological survey objectives, whilst minimising acoustic input into the marine environment, would help satisfy this RMA requirement.

SLR Consulting New Zealand Limited (SLR) has been engaged to prepare a Marine Mammal Impact Assessment (MMIA) in accordance with the Code of Conduct in order to assess the potential environmental effects from the 18SBB3D seismic survey. The MMIA also sets out the measures that will be employed to avoid, remedy or mitigate any potential environmental effects.

1.2 General Approach

This MMIA outlines the measures that TEMS will undertake to ensure the 18SBB3D seismic survey is in compliance with:

- the EEZ Act;
- other relevant New Zealand legislation;
- relevant international conventions; and
- internal environmental standards.

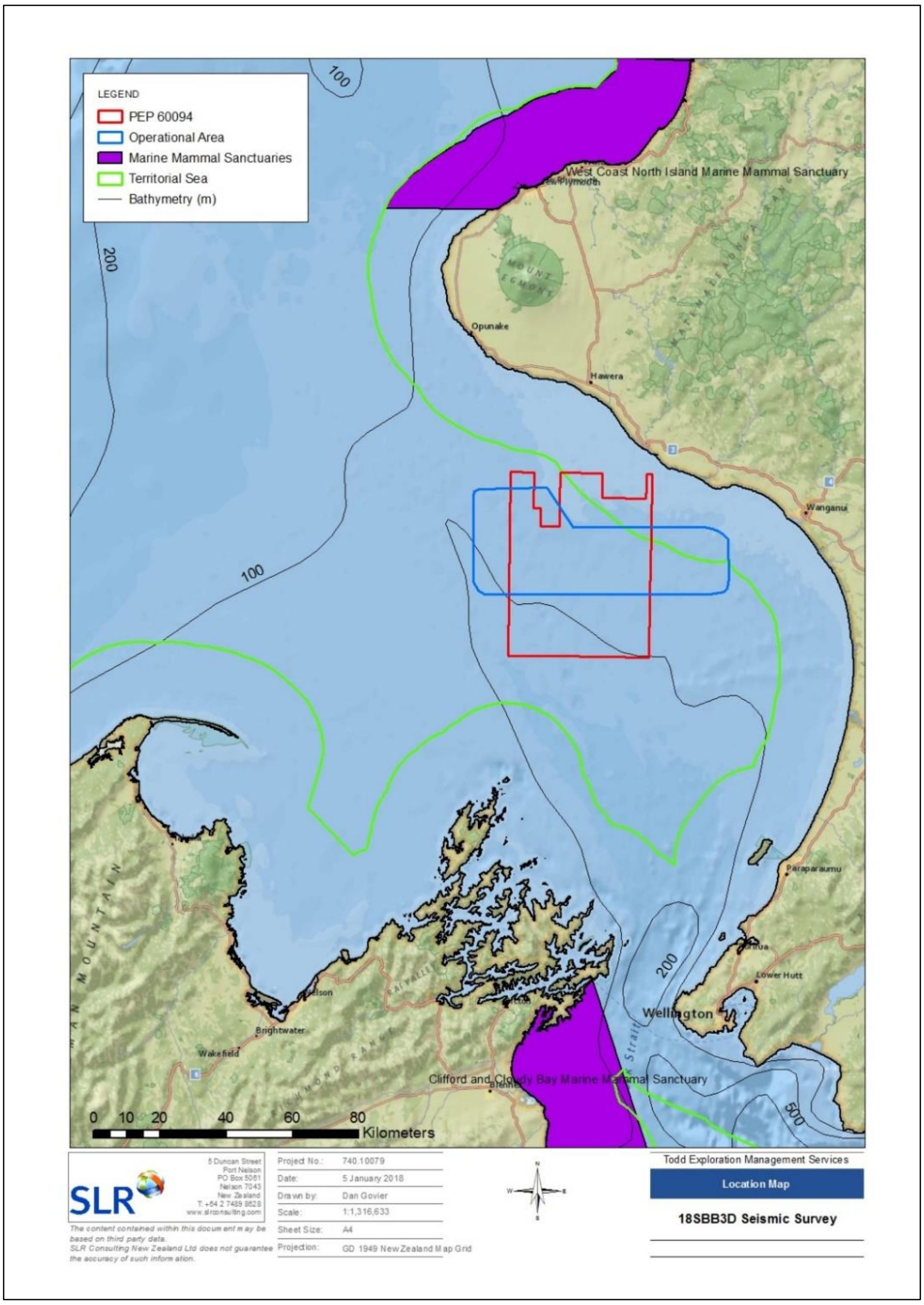
[1] For the purpose of this MMIA, the ‘South Taranaki Bight’ as defined as the marine and coastal area that lies between the North and South Islands of New Zealand (38°49’S to 40°53’S, 171°37’E to 175°13’E) following Torres (2013).

The EEZ Act, other relevant New Zealand legislation and relevant international conventions are further described in **Section 3**

On account of the proposed acoustic source being greater than 427 cubic inches, the 18SBB3D seismic survey is classified as a 'Level 1 Survey' (DOC, 2013). The Code of Conduct requirements of a Level 1 marine seismic survey are outlined in **Section 3.5**. **Section 7** summarises all measures that TEMS will commit to in order to minimise their environmental effects, many of these measures go above and beyond what is required by the Code of Conduct.

During the preparation of this MMIA, an extensive review of literature and existing data on the environment surrounding the Operational Area has been undertaken (see **Section 4**). A full list of references is provided in **Section 9**.

Figure 1 Location of the 18SBB3D Seismic Survey Operational Area



2 PROJECT DESCRIPTION

2.1 Marine Seismic Surveys - overview

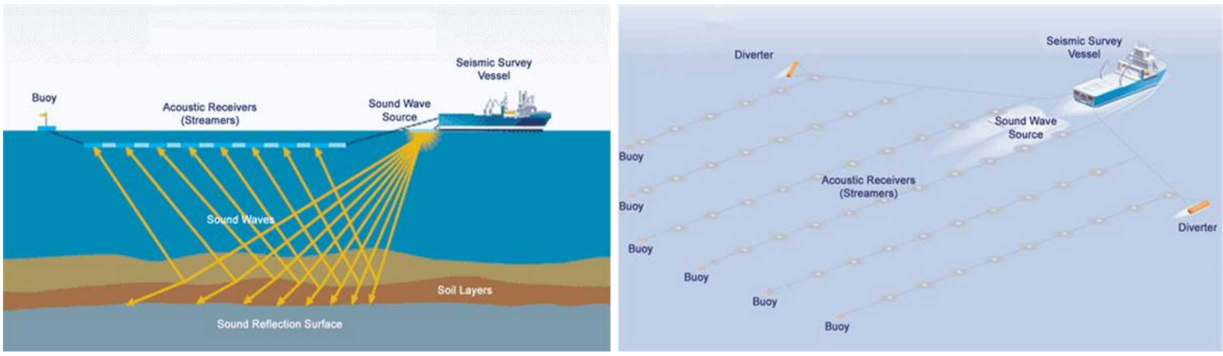
The principle behind a marine seismic survey is that an energy source (i.e. acoustic source) instantaneously releases compressed air which generates a directionally focused acoustic wave at low frequency that travels several kilometres through the earth. Portions of this acoustic wave are reflected by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

2.1.1 2D and 3D surveys

Marine seismic surveys fall into two main categories of varying complexity: 2-dimensional (2D) and 3-dimensional (3D) surveys. A 2D survey is a basic survey method which involves a single source and a single streamer towed behind the seismic vessel (**Figure 2**). In contrast, a 3D survey is a more complex method which involves a greater span of equipment to provide a more detailed image of the earth's strata (**Figure 2**).

The purpose of a 3D marine seismic survey is to focus on a specific area where the geology needs to be understood at a level of detail that 2D surveying cannot provide. Extensive planning is undertaken to ensure the survey area is precisely defined and the acoustic parameters are selected in order to achieve the best geological results. 3D surveys produce a three-dimensional image of the subsurface.

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



(Source: www.fishsafe.eu)

2.1.2 Underwater sound

Underwater sound has two primary measures:

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

Sound levels in water are not the same as sound levels in air and confusion often arises when trying to compare the two. The reference level of the amplitude of a sound must always be specified. For sound in water the reference level is expressed as 'dB re 1µPa' – 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 differences, currents, etc.). Given that sound level in water reduces by 6 dB as the distance doubles, high levels of sound are only experienced very close to the source. Furthermore, the loudness of a sound in water diminishes very quickly close to the source and more slowly at distance from the source.

The ocean is a naturally noisy environment. Natural sound inputs include wind, waves, marine life, underwater volcanoes and earthquakes. Man-made sounds such as shipping, fishing, marine construction, dredging, military activities, sonar etc. further add to the underwater noise profile. The sound produced during seismic surveys is comparable in loudness to a number of naturally occurring and man-made sources such as those provided in **Table 1**.

Table 1 Sound Comparisons in Air and Water

Type of Sound	In Air (dB re 20µPa @ 1m)	In Water (dB re 1µPa @ 1m)
Threshold of Hearing	0 dB	62 dB
Whisper at 1 metre	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
Seismic array at 1 metre	158 – 178 dB	220 – 265 dB
Colliding iceberg	-	220 dB
Bottlenose dolphin	-	225 dB
Sperm whale click	-	236 dB
Jet engine take-off at 1 metre	180 dB	242 dB
Volcanic eruption	-	255 dB
18SBB3D source level at 100 m		191 dB
18SBB3D source level at 1,000 m		174 dB

2.1.3 The acoustic source

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

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 and continuously enabling the source arrays to be fired every few seconds.

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

Acoustic arrays used by the oil and gas industry are designed to emit most of their energy at low frequencies, typically 20-50Hz 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 1µPa-m_{p-p}) (Richardson et al., 1995). However, the overall amplitude depends on how many elements are in each array and the combined volume discharged by those elements. Tuning of source elements also needs to be taken into account. There are typically two identical arrays that are activated alternately during a seismic survey.

2.1.4 The streamers

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

Towing a streamer underwater removes it from potential acoustic interference from the sea surface. The deeper the tow depth, the quieter the streamer in regard to background surface noises; however, this also results in a narrower range of frequencies being recorded which reduces the overall data quality. Typical streamer operating depths range from 4 to about 25 m depending on the imaging requirements and bathymetry.

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

2.2 18SBB3D Seismic Survey

The Operational Area for the 18SBB3D seismic survey in the South Taranaki Bight is located off the west coast of the southern North Island, between Hawera and Whanganui (**Figure 1**). Water depths within the Operational Area range from approximately 30 to 100 m and survey lines will run in an east-west orientation. Athough the shallowest water depth in the Operational Area is 30 m, the survey vessel will not operate in waters less than 40 m water depth with the streamers deployed in the planned configuration. Note that TEMS have taken a conservative approach in the preparation of this MMIA and associated risk assessment, and likewise the verification of the mitigation zones by the Sound Transmission Loss Modelling (STLM), by using a water depth of 30 m for the worst case scenario rather trhan the expected minimum depth of 40 m (**Section 6.2.2.1**).

The survey objective is to determine whether the modern 3D technology available on the *MV Amazon Warrior* will provide imaging of the subsurface Taranaki Fault Zone, and at high enough resolution to assess the geological structure of the Taranaki Boundary Fault, given all previous seismic data across the permit has failed to adequately image the area of interest. As a result, TEMS plans to undertake a small 3D seismic programme in 2018. If the 2018 3D seismic survey programme proves successful, TEMS may propose a further 3D programme at some stage in the future to fully understand the prospective area.

The acoustic source will be comprised of three sub-arrays, with an effective volume of 5,085 in^3. The source will be towed at a depth of 7.5 m below the sea surface and will have an operating pressure of 2,000 psi. Source activation will occur at intervals of 25 m, which at a vessel speed of 4.5 knots, equates to every 10.8 seconds. The survey specifications are provided in **Table 2**.

Table 2 Seismic Survey Specifications

Parameter	Specifications
Source type	Boltgun
Source volume	5,085 in^3
Maximum predicted output	262 dB re 1µPa @ 1m (peak to peak)
Number of sub-arrays per source	3
Number of elements per sub-array	8 - 8 - 8
Nominal operating pressure	2,000 psi
Source Frequency	25 m (flip flop between two source arrays)
Source Depth	7.5 m
Number of streamers	14
Streamer separation	110 m
Streamer length	8 km
Streamer manufacturer/model	Q-Marine Solid Streamers
Streamer tow depth	Flat deep tow 12 m or greater

During the 18SBB3D seismic survey, 14 solid streamers (Q-Marine Solid™) of approximately 8 km in length will be towed by the seismic vessel. Each streamer will be separated by 110 m and will be towed at a flat depth of at least 12 m. Solid streamers have a number of advantages over fluid filled streamers; they are more resistant to damage (e.g. shark bites), they require less frequent repairs, and they are steerable, allowing greater control and therefore efficiency. If the vessel has to 'wait on weather' during the acquisition period, the acoustic source will typically be retrieved to minimise the potential for damage; however, the streamers will only be retrieved in extreme situations.

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

The 18SBB3D seismic survey may run a system of 'continuous line acquisition'; by shortening the acquisition lines and acquiring data during turns. This technique optimises vessel use and typically reduces the overall survey duration by about 20%.

The proposed survey is scheduled for February 2018. Subject to weather conditions and marine mammal shut-downs, the survey operations will be conducted 24 hours per day, with the seismic survey operations expected to take up to five days to complete.

The seismic vessel *MV Amazon Warrior* (**Figure 3, Table 3**) will be used to undertake the survey and will be accompanied by a support vessel and a chase vessel (**Figure 4, Table 4**). The support vessel will be in close proximity to the seismic vessel at all times with the exception of those periods when the support vessel is needed for a port call. The chase vessel will be utilised for the duration of the survey to check bathymetry and to ensure there are no vessels or objects ahead of the *MV Amazon Warrior*. Refuelling of the seismic vessel is unlikely during the short duration of the survey; however, if refuelling is required during the survey due to the previous survey, it will occur at sea, and the mitigations that will be implemented are discussed in **Section 6.3.3.**

Table 3 *MV Amazon Warrior* Technical Specifications

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

Table 4 Support Vessel Technical Specifications

General Specifications	**Mermaid Searcher**	**MV Sea Ranger**
Vessel Owner	MMA Offshore	Seaworks
Maritime Operator	MMA Offshore	Seaworks
Engine Details	Cummins KTA50-M42 1600 bhp	2 x Cummins KTA50M2, total 3244 HP
Fuel Capacity	926 m^3	275 m^3
Dimensions and capacities		
Vessel Length	54 m	32 m
Vessel Beam	13.8 m	9.15 m
Max Draft	3.6 m	3.68 m
Gross Tonnage	1,079 tonnes	336 tonnes
Max Speed	12.5 knots	12 knots
Transit Speed	9 knots	9 knots

Figure 3 Seismic Vessel – *MV Amazon Warrior*

Figure 4 Support Vessels – *MV Mermaid Searcher* (left) and *MV Sea Ranger* (right)

2.3 Survey design considerations and alternatives

The source level and array configuration for the 18SBB3D seismic survey was selected in order to provide sufficient power to fulfil the geological survey objective, whilst minimising acoustic input into the marine environment. A source level of 5,085 in³ has been identified as a suitable power level given the survey objectives.

The initial Operational Area that TEMS proposed for this survey approached to approximately 4 km of the coast near Hawera. However following discussions with SLR during the survey design phase, the inshore boundary of the Operational Area was revised to reduce the potential for acoustic disturbance in shallow coastal waters, in particular to mitigate against any potential behavioural impacts on Maui's dolphins in the unlikely event they should be present in this area. The alteration to the Operational Area (initial and revised) is illustrated in **Figure 5**.

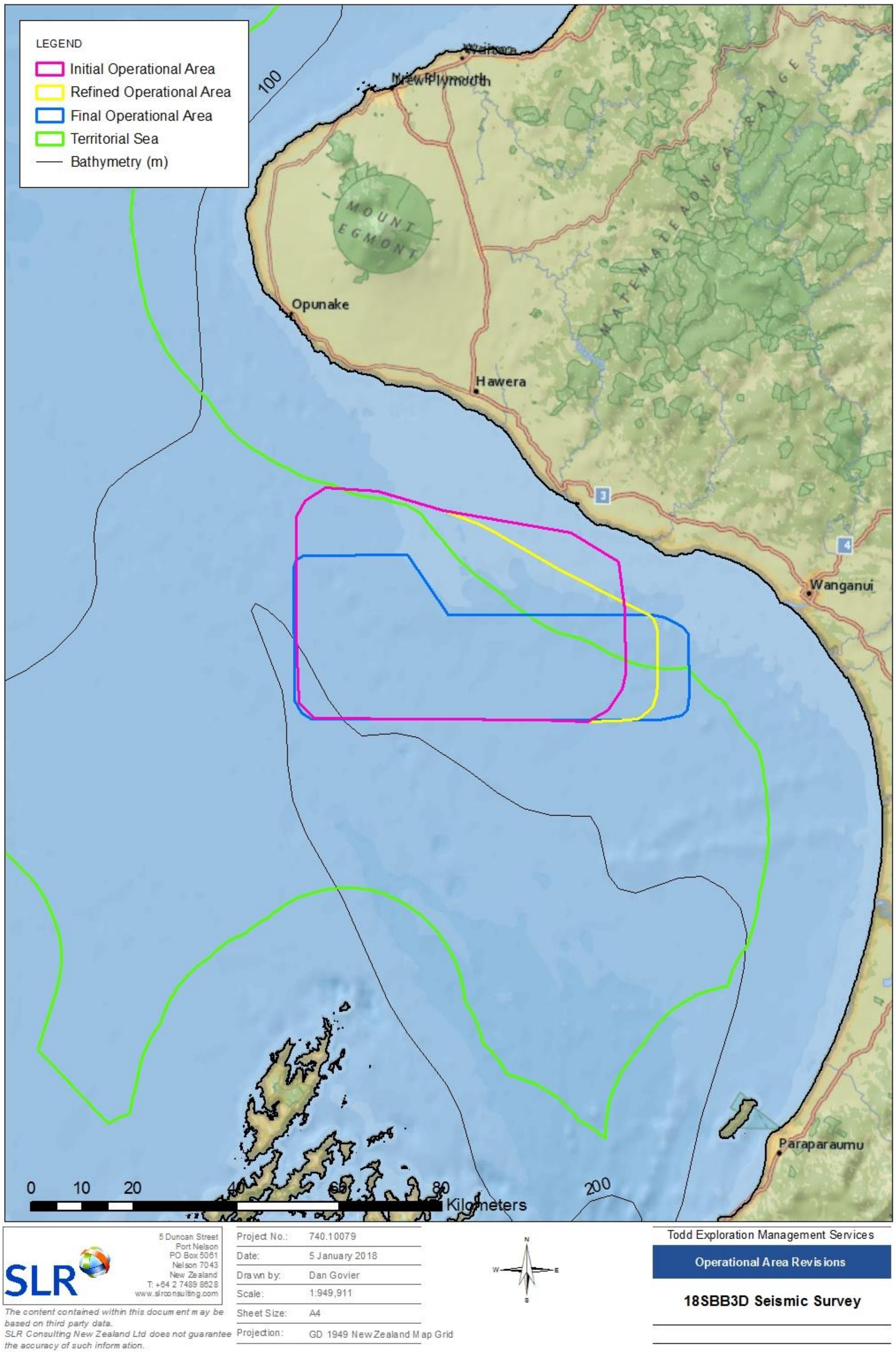
In addition, seismic operations will be undertaken during the summer period in order to take advantage of the settled summer weather. This intended timing not only makes for more amenable working conditions for crew, but also serves to reduce environmental impacts by minimising down-time which ensures that the duration of the survey is as short as possible, and by minimising the overlap with winter whale migrations in the South Taranaki Bight. Acquiring the survey in summer daylight hours also increases the length of visual observation for marine mammals that can be undertaken each day. Conversely, the intended timing also increases the potential environmental effects on blue whales feeding in the South Taranaki Bight over the summer months (see **Section 6.2.2.5**).

2.4 Navigational Safety

During the 18SBB3D seismic survey, the seismic vessel will have severely restricted manoeuvrability on account of the towed equipment. Avoidance of collision will rely on all vessels obeying the International Regulations for the Prevention of Collisions at Sea (COLREGS) 1972. The COLREGS are implemented in New Zealand waters under the Maritime Transport Act 1994. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the presence of the seismic vessel in the Operational Area and the vessel's restriction in ability to manoeuvre while the streamers are deployed. The seismic survey vessel will have Automatic Identification System (AIS) technology on-board, allowing the vessel to receive information about the positions of other vessels and to transmit information about its position to others.

Other marine users of the Operational Area have been provided with information during the engagement process. Furthermore, the chase vessel will notify boats that are unaware of the seismic operations as necessary. In accordance with International Maritime Law, the survey vessels will display the appropriate lights and day shapes while undertaking the survey. Tail buoys equipped with a light and radar reflector will mark the end of the streamers, allowing for detection day and night.

Figure 5 Revisions to the Operational Area during Survey Planning



3 LEGISLATIVE FRAMEWORK

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

The legislative framework, relating to the 18SBB3D seismic survey is described below.

3.1 Crown Minerals Act 1991

The Crown Minerals Act 1991 sets the broad legislative framework for the issuing of permits for prospecting, exploration and mining of Crown-owned minerals in New Zealand, which includes those minerals found on land and offshore to the boundary of the extended continental shelf. 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. See **Section 4** for information regarding the engagement that was undertaken for the 18SBB3D seismic survey.

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

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

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

The EEZ Act classifies activities within the EEZ and continental shelf as:

- **Permitted** – the activity can be undertaken provided the operator meets the conditions specified within the regulations. Seismic surveys fall within this classification and the conditions state that the person undertaking the activity must comply with the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*;
- **Non-notified discretionary** – the activity can be undertaken if the applicant obtains a marine consent from the Environmental Protection Authority (EPA), who may grant or decline the consent and place conditions on the consent. The consent application is not publically notified and the EPA has a statutory timeframe of 70 working days in which to process the application;
- **Discretionary** – the activity may be undertaken if the applicant obtains a marine consent from the EPA. The consent application will be notified, submissions will be invited and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 150 working days in which the EPA must assess the consent application; and
- **Prohibited** – the activity may not be undertaken.

The EPA monitors for compliance of seismic surveys in accordance with the Code of Conduct, and may conduct audits of seismic vessels before, during, or after the survey. The EPA has the authority to take enforcement action in relation to any non-compliant activities during the 18SBB3D seismic survey.

3.3 Resource Management Act 1991

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

The Operational Area of the 18SBB3D seismic survey overlaps with the CMA between Hawera and Wanganui (**Figure 1**). In the CMA, seismic surveying is considered to be a permitted activity as long as operations comply with the Code of Conduct (as specified in the draft Taranaki Regional Coastal Plan which is due to be notified in early February 2018), and compliance with the Code of Conduct is understood to satisfy s16 of the RMA.

Seismic surveys are permittied activities in Taranaki coastal waters (within the CMA) under the existing Taranaki Regional Coastal Plan (2007) on the provision that the following conditions are met:

- The survey does not involve placement of explosives or does not otherwise directly involve disturbance of the foreshore or seabed; and
- The survey is not conducted in an area that is used by marine wildlife for breeding purposes during the time that those animals are breeding.

The 18SBB3D seismic survey will not result in direct disturbance to the seabed and will not involve the use of expolsives. Potential overlap between seismic survey operations and the breeding habitat of coastal marine wildlife has also been addressed. Breeding behaviour has been interpreted to mean ‘mating’ and ‘parturition’ (calving or pupping). With regard to breeding behaviour, the following have been noted:

- Calving of southern right whales around mainland New Zealand occurs in shallow waters during winter months, with cow/calf pairs observed in Taranaki coastal waters in winter. As the 18SBB3D seismic survey will occur in summer/early autumn 2018 there is no temporal overlap expected between southern right whale breeding activities and survey operations (see **Section 5.2.1.6** for further information on southern right whales);
- Calving of Māui’s dolpins occurs from November to mid-February in shallow coastal waters of less than 100 m water depth. Their population concentration lies well north of the Operational Area, with very low densities occurring south of New Plymouth (Currey et al., 2012), therefore no significant spatial overlap is predicted between survey operations and Māui’s dolphin breeding activities (see **Section 5.2.1.17** for further information on Māui’s dolphins);
- The closest New Zealand fur seal breeding colony to the Operational Area is located at the Sugar Loaf Islands off New Plymouth. Peak pupping occurs in mid-December, with pups remaining at the breeding colony from birth until weaning at 8 – 12 months old (Baird, 2011). There is no spatial overlap predicted between survey operations and New Zealand fur seal breeding activities (see **Section 5.2.2.1** for further information on this species);
- Although mother and calf pairs of pygmy blue whales have been observed in the South Taranaki Bight, no actual mating or calving has been documented. Mothers with young calves could from time to time enter the Operational Area, but the effect of such spatial overlap is expected to be no more than minor on account of:
    - The area of overlap (territorial sea within the proposed Operational Area) is small;

  - To data all mother/calf sightings have occurred beyond 12 M from shore (Torres et al., 2017); and
  - The DOC Marine Mammal Sighting Database does not include any mother/calf sightings within the Operational Area.
- There is no information to suggest that South Taranaki's coastal waters are of particular importance as breeding habitat for any other marine mammal species. Some species (e.g. common dolphins) may mate and give birth anywhere throughout the South Taranaki Bight, including in the territorial sea.

3.4 Marine Mammals Protection Act 1978

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

Restrictions can be placed on seismic surveys in Marine Mammal Sanctuaries to prevent or minimise disturbance to marine mammals. In order to conduct a seismic survey within a Marine Mammal Sanctuary, the Code of Conduct requires that an operator must notify the Director-General of DOC and submit a written Environmental Impact Assessment not less than three months before commencing the survey. The operator must also comply with any additional conditions that are imposed by DOC relating to operations within the sanctuary; in particular, Gazette Notices may place specific restrictions on seismic surveys within a sanctuary.

The closest Marine Mammal Sanctuary to the proposed Operational Area is the West Coast North Island Marine Mammal Sanctuary; which lies approximately 85 km to the north. A full description of the sanctuary can be found in **Section 5.3.2.**

3.5 International regulations and conventions

The following international regulations and conventions will be adhered to throughout the duration of the 18SBB3D seismic survey:

- International Regulations for the Prevention of Collisions at Sea 1972 (the COLREGS); provide an international set of operational expectations and navigation procedures to prevent collisions at sea. New Zealand ratified the convention in 1972, and the COLGRES are implemented in New Zealand waters under the Maritime Transport Act 1994; and
- The International Convention for the Prevention of Pollution from Ships 1973 (the MARPOL Convention): addresses the prevention of ship-based marine pollution from operational and accidental discharges. The MARPOL Convention has been updated by amendments and associated protocols. Provisions of relevance relate to the discharge of oil water from machinery spaces, and discharge of sewage and garbage. Discharges are further discussed in **Section 6.2.3**.

3.6 2013 Code of Conduct

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

The Code of Conduct aims to:

- Minimise disturbance to marine mammals from seismic survey activities;

- Minimise noise in the marine environment arising from seismic survey activities;
- Contribute to the body of scientific knowledge on the physical and behavioural impacts of seismic surveys on marine mammals through improved, standardised observations and reporting;
- Provide for the conduct of seismic surveys in 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 cubic inches) are typically large scale geophysical investigations, Level 2 surveys (151 – 426 cubic inches) are lower scale seismic investigations often associated with scientific research, and Level 3 surveys (<150 cubic inches) include all small scale, low impact surveys. The 18SBB3D seismic survey is classified as a Level 1 survey. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

3.6.1 Notification

As required by Paragraph 2, section 3.1 of the Code of Conduct, notification was submitted to the Director-General of Conservation by TEMS (on 4 December 2017) of the intention to carry out the 18SBB3D seismic survey. Evidence has been supplied explaining the exceptional or opportunistic nature of the survey under Paragraph 2 clause 3.1 of the Code of Conduct.

3.6.2 Marine Mammal Impact Assessment

Under normal circumstances, an MMIA must be submitted to the Director-General not less than one month prior to the start of a seismic survey, however in exceptional or opportunistic circumstances the Code of Conduct permits an MMIA to be submitted no less than two weeks before the commencement of the survey. Each MMIA is required 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.

3.6.3 Areas of Ecological Importance

Any seismic survey operations within an Area of Ecological Importance require more comprehensive planning and consideration, including additional mitigation measures to be developed and implemented through the MMIA process.

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

The Code of Conduct states that, under normal circumstances, a seismic survey will not be planned in any sensitive, ecologically important areas; during key biological periods where Species of Concern (see **Table 9**) are likely to be feeding, migrating, calving, or resting; or where risks are particularly evident such as in confined waters.

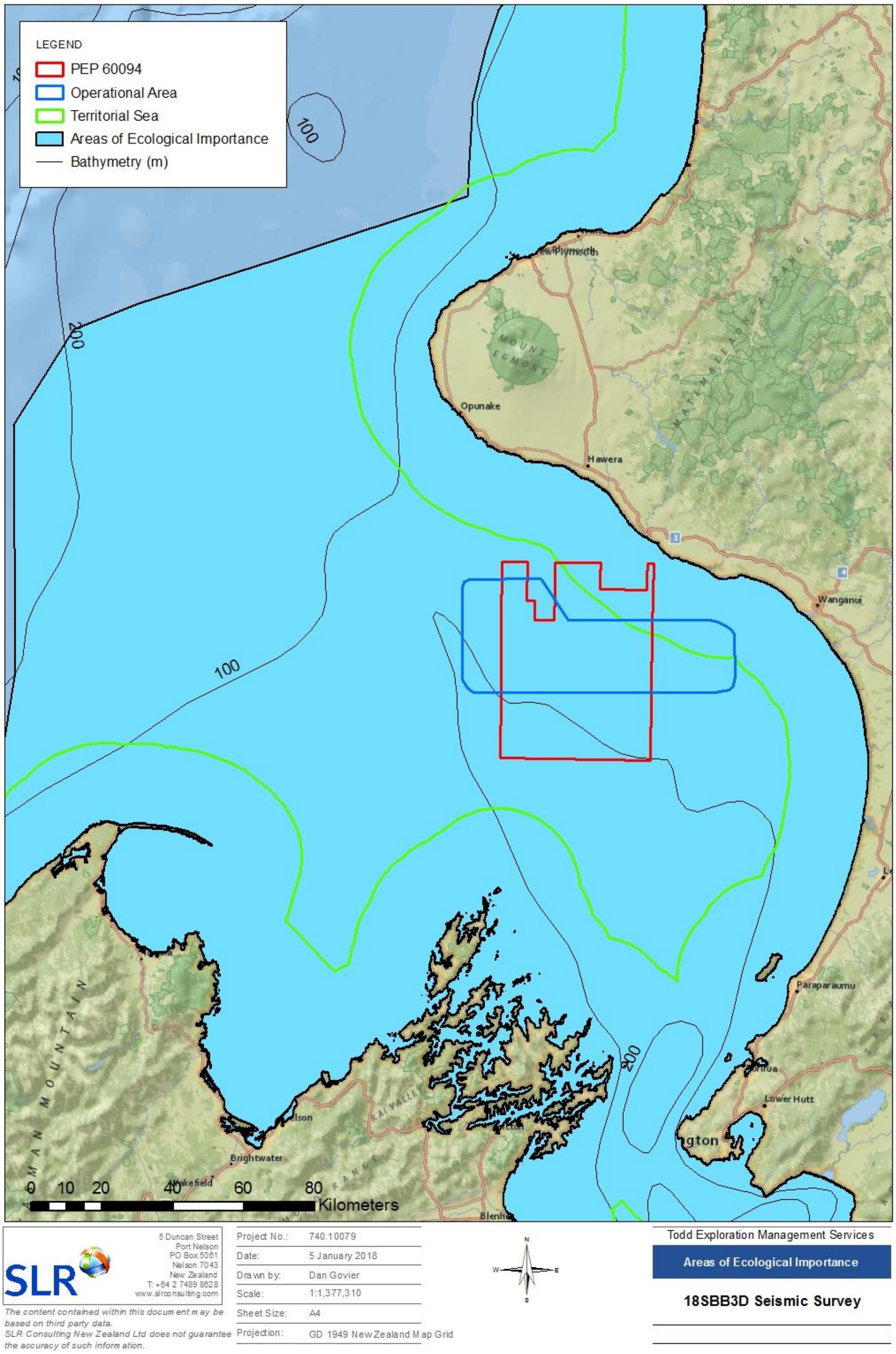
The 18SBB3D survey will largely occur within the Area of Ecological Importance (**Figure 6**). Measures that TEMS will implement to offset this are summarised in **Section 7**.

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 Operational Area. The model results indicate whether or not the 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 occurif marine mammals are subject to Sound Exposure Levels (SELs) greater than 171 dB re 1µPa2.s, Temporary hearing loss is referred to as a 'Temporary Threshold Shift' (TTS) 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 1µPa2.s. Permanent hearing loss is referred to as a 'Permanent Threshold Shift' (PTS) and is discussed further in **Section 6.2.2.2.1**).

If the modelling predicts exceedances of these thresholds, then consideration must be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. Results from the 18SBB3D seismic survey STLM are discussed in **Section 6.2.2.1**.

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



3.6.4 Observer Requirements

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

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

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

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

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

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

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

3.6.5 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 at the earliest opportunity, but no longer than 14 days after the completion of each deployment. A written final trip report must also be provided to DOC at the earliest opportunity, but no later than 60 days after the completion of the project.

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

Table 5 Operational Duties of MMOs and PAM Operators

Operational duties	
MMO duties	**PAM operator duties**
Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations	Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations
Continually scan the water surface in all directions around the acoustic source for presence of marine mammals, using a combination of naked eye and high-quality binoculars from optimum vantage points for unimpaired visual observations	Deploy, retrieve, test and optimise hydrophone arrays
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards or other appropriate tool	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, 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
Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct	Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct

3.6.6 Pre-start Observations

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

- The acoustic source cannot be activated during daylight hours unless:
  - At least one qualified MMO has made continuous visual observations around the source for the presence of marine mammals, from the bridge (or preferably even higher vantage point) using both binoculars and the naked eye, and no marine mammals have been observed in the respective mitigation zones for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes; and

   - Passive acoustic monitoring (PAM) for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the respective mitigation zones.

- The acoustic source cannot be activated during night-time hours or poor sighting conditions (visibility of 1.5 km or less or in a sea state greater than or equal to Beaufort 4) unless:
   - Passive acoustic monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation; and
   - The qualified observer has not detected any vocalising cetaceans in the relevant mitigation zones.

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

- MMOs have undertaken observations within 20 M 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 M 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.

For the 18SBB3D seismic survey, the proposed plan is for the Schlumberger Western Platform survey to finish with the well tie line into the Kupe Field. This well tie swath will enter into the TEMS Operational Area, with the intention to start acquiring the TEMS survey immediately. As a result of this acquitison plan, there is no requirement for any additional pre-start observations given the acoustic source has been active within the TEMS Operational Area prior to commencing the survey. This plan is envisaged to minimise the effects of acoustic disturbance to marine mammals who may return to the general area while a source shut-down is implemented for pre-start observations.

3.6.7 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.

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

3.6.8 Delayed Starts and Shutdowns

The 18SBB3D seismic survey will require a deviation from the standard Code of Conduct requirements with regards to delayed starts and shut downs with an increased mitigation zone for Species of Concern. This is outlined below.

Species of Concern with or without calves within a mitigation zone of 1.5 km

The results of the STLM, (see **Section 6.2.2.1**) indicated that the 1 km mitigation zone, as outlined in the Code of Conduct, for delayed starts and shutdowns may be insufficient to protect marine mammals (without calf) from behavioural disturbance during the 18SBB3D seismic survey. For this reason, larger mitigation zones have been adopted for Species of Concern as follows.

While the acoustic source is activated (including during soft starts), a qualified observer detects at least one Species of Concern (with or without a calf) within 1.5 km of the source, start-up will be delayed or the source will be shut down and not reactivated until:

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

Other Marine Mammals within a mitigation zone of 200 m

With regards to the detection of other marine mammals, the standard Code of Conduct mitigation zone is appropriate for all operations. The standard mitigation zone for other marine mammals is as follows:

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

- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m from the source; or
- Despite continuous observation, 10 minutes has elapsed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m of the source, and the mitigation zone remains clear.

4 ENGAGEMENT

TEMS regards honest and effective engagement as critical to its success and viability. The key to this is continuous proactive engagement, listening and responding to evolving concerns, understanding and tailoring the programme to the needs of different key relationships.

In preparation for the 18SBB3D seismic survey, TEMS have undertaken, and will continue to undertake engagement with key relationships, stakeholders and tangata whenua. In the interest of proactive engagement, TEMS has met with some existing key relationships and tangata whenua related to TEMS's onshore operations (initial meetings to provide some brief information on the survey were held even before the notification to NZP&M and DoC), and other key stakeholders.

A letter was sent to all the key relationships and stakeholders. The letter consisted of an overview of the seismic location, planned operations and highlighted the following mitigation measures:

- The presence of independent Marine Mammal Observers on board the seismic vessel;
- 24 hour PAM to listen for Cetacean calls alerting the vessel to their presence;
- A period of pre-start observations for Marine Mammals before activating the acoustic source in a graduated manner (soft start) following any shut-downs during the survey; and
- Shutting down of the acoustic source if Marine Mammals enter the mitigation zones during seismc survey operations.

All groups that were sent a letter are summarised in **Table 6.**

Table 6 Groups with which engagement has occurred

Iwi	
Ngati Mutunga	Taranaki
Te Atiawa	Nga Ruahine
Te Atiawa (Taranaki) - Ngati Rahiri	Ngati Ruanui
Te Atiawa (Taranaki) - Otaraua	Nga Rauru Kitahi
Ngati Manuhiakai	Manawhenua ki Mohua
Ngati Apa	Ngati Tu
Ngati Rangi	To Kaahui o Rauru
Other	
Department of Conservation – Head Office	Department of Conservation – Taranaki
Environmental Protection Authority	Department of Conservation - Takaka
Taranaki Regional Council	New Plymouth Sport Fishing & Underwater Club
Deepwater Group	NIWA
Southern Inshore Fisheries	Forest & Bird
Egmont Seafoods	Horizons Regional Council
Auckland University	Trans-Tasman Resources
Whanganui River Maori Trust Board	Project Jonah
Port Taranaki	Oregon State University
New Zealand Federation of Commercial Fishermen	Taranaki Recreational Fishing Council
Patea and Districts Boating Club	Fisheries Inshore NZ
Cape Egmont Boat Club	Taranaki Commercial Fishermen's Association
Ohawe Boating and Angling Club	

All letter recipients have been offered the opportunity to meet and discuss further. TEMS' process involves phoning all key relationships, stakeholders and tangata whenua to check if they would like a meeting or have any concerns they would like to discuss further. These meetings provided a brief overview of the survey followed by in-depth discussion with stakeholders if required. TEMS will be available to meet with key stakeholders throughout the survey operations and following completion of the survey if requested.

A register of the key points discussed during the engagement process is included as **Appendix B**. Of note, a discussion with Forest and Bird has resulted in changes to the description in this MMIA of "data deficient" species of concern, with respect to the NZ threat classification system.

The primary commitments made by TEMS during the engagement process are summarised as:

- Immediate notification of Hector's/Maui's dolphin sighting information to DOC Taranaki;
- Collection of marine mammal sighting information whilst 'off-survey' (i.e. outside those times when marine mammal sightings are a requirement of the Code of Conduct);
- Local Iwi MMOs and PAM operators will be provided with employment opportunities during the survey;
- Post-survey engagement will occur to convey key survey outcomes; and
- Provision of the draft MMIA to all parties interested in receiving a copy prior to acceptance by DoC.

The engagement process has helped to shape this MMIA and has uncovered a number of items that Todd will consider when planning future surveys.

5 DESCRIPTION OF THE OPERATIONAL AREA

5.1 Physical Environment

5.1.1 Meteorology

The climate of New Zealand is complex, varying from warm subtropical in the far north to cool temperate in the far south. Anticyclones are a major feature of New Zealand's weather in the region as they migrate eastwards across the country every six to seven days. Overall, anticyclones follow northerly paths in the spring and southerly paths in the autumn and winter. As each anti-cyclone moves off the east coast, north-westerly winds commonly bring cold fronts onto the country. Cold fronts are followed by troughs of low pressure characterised by increased cloud cover, intensifying north-westerly winds and precipitation which persists until the front passes eastward (Te Ara, 2017). After the front has passed, the weather conditions change again to cold showery south-westerly winds, before the arrival of the next anticyclone.

The Operational Area, which encompasses the Patea Shoals in the South Taranaki Bight (Hadfield & Macdonald, 2015), is exposed to intense weather systems from the Tasman Sea where Taranaki is one of the windiest regions in New Zealand and the most frequent winds generally originate from the west (Chappell, 2014). Weather in the Taranaki Basin has few climatic extremes, but can be extremely changeable; winters are generally more unsettled. Whanganui weather conditions have been used as indicative for the Operational Area. Mean monthly weather parameters at Whanganui are shown in **Table 7**.

Table 7 Mean Monthly Weather Parameters at Whanganui

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	45	53	45	60	60	87	72	55	70	86	72	77
Temp – Avg. daytime (°C)	22	23	21	18	16	13	12	13	15	16	18	20

Temp –avg. night time (°C)	13	13	11	9	7	5	5	5	7	8	9	12
Avg. wind speed (kts)	9	8	8	7	7	7	7	8	9	10	10	9
Max. wind speed (kts)	29	35	29	27	33	29	27	35	39	43	35	33

Source: MyWeather2, 2017

5.1.2 Currents and Waves

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 of these components, often further influenced by the local bathymetry.

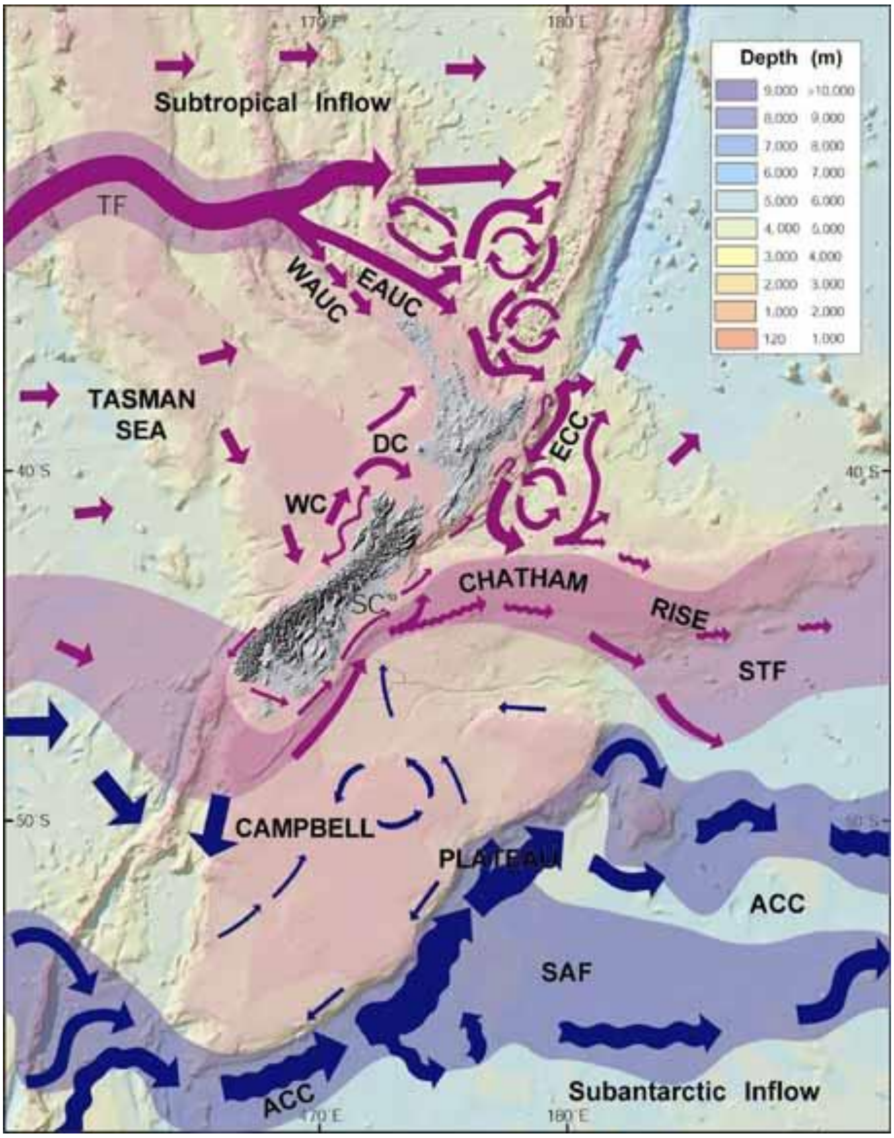
New Zealand lies in the pathway of eastward-flowing currents driven by winds blowing across the South Pacific Ocean (Brodie, 1960). This results in New Zealand being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the Roaring Forties westerly winds to the south (Gorman et al., 2005).

The primary ocean currents around the New Zealand coastline are illustrated in **Figure 7**. The eastward flow out of the Tasman Sea splits into two currents across the top of the North Island; the West Auckland Current (WAUC) flowing from Cape Reinga towards Kaipara, and the East Auckland Current (EAUC) flowing from North Cape towards the Bay of Plenty (Brodie, 1960; Heath, 1985; Stanton, 1973). As the West Auckland Current progresses south, it is met in the North Taranaki Bight by the north-flowing Westland Current (WC). The Westland Current courses 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 (i.e. the northern limit of the Westland Current and the southern limit of the West Auckland Current) (Brodie, 1960; Ridgway, 1980; Stanton, 1973).

Seasonal variation in the West Auckland Current and Westland Currents result in varying temperatures and salinity off the Taranaki coastline. During winter, the West Auckland Current extends further south, bringing with it warmer waters. In contrast, the West Auckland Current is weaker in the summer months and the Westland Current dominates, bringing with it colder waters (Ridgway, 1980; Stanton, 1973). Additional areas of cold surface water can also be found off the Taranaki coastline; however, these are thought to be caused by land water run-off (Ridgway, 1980).

The tidal phase between the western and eastern ends of Greater Cook Strait result in typically strong tidal currents in the South Taranaki Bight (MacDiarmid et al., 2015; Hadfield & Macdonald, 2015). The Cook Strait reaches currents of over 1.7 ms^{-1}, but nearer the South Taranaki Coast the current peak decreases. For instance, in the shallow waters of Patea as well as in the nearshore region near Manaia (indicative of the Operational Area), the maximum current is 0.4 ms^{-1} (MacDiarmid et al., 2015). The current flows largely parallel to the shore (MacDiarmid et al., 2015; Hadfield & Macdonald, 2015: Hume et al., 2015) and reduces southeast of the Patea Banks, where peaks of less than 0.1 ms^{-1} are characteristic of nearshore waters between Whanganui and Foxton (MacDiarmid et al., 2015).

Figure 7 Ocean Circulation around the New Zealand Coastline



Source: http://www.teara.govt.nz/en/map/5912/ocean-currents-around-new-zealand

Due to its location in the Tasman Sea, the Operational Area is situated in a high energy wave climate; most of the wave energy in the South Taranaki Bight comes from large southwest swells from the Southern Ocean and locally generated wind waves from the Tasman Sea that vary seasonally in size and direction (Hume et al., 2015).

Wave heights in the South Taranaki Bight show a seasonal cycle, with mean significant wave heights peaking in late winter (August and September) and lowest in late summer (MacDiarmid et al., 2015). Data from a 20 year hindcast, in the South Taranaki Bight, across the 50 m isobath has shown that the largest waves occur off the western end of the Taranaki Peninsula and decrease as you move south with increasing shelter from prevailing SW swell (Hume et al., 2015). The peak wave period is typically around 12 seconds and the mean wave height close to the Operational Area has been found to peak at around 1.9 m off Patea and 1.8 m off Waitotara (Hume et al., 2015) but significant wave heights in excess of 8 m can occur during stormy conditions, particularly in the winter and early spring (Hume et al., 2015; MacDiarmid et al., 2015).

5.1.3 Thermoclines and Sea Surface Temperature

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

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

Macdonald et al. (2015) found that the water column in the South Taranaki Bight was generally well mixed with only small vertical differences in temperature, where surface waters were slightly warmer than further down and the temperature ranged between 12.5^{o}C – 19^{o}C deoending on time of year.

5.1.4 Bathymetry and Geology

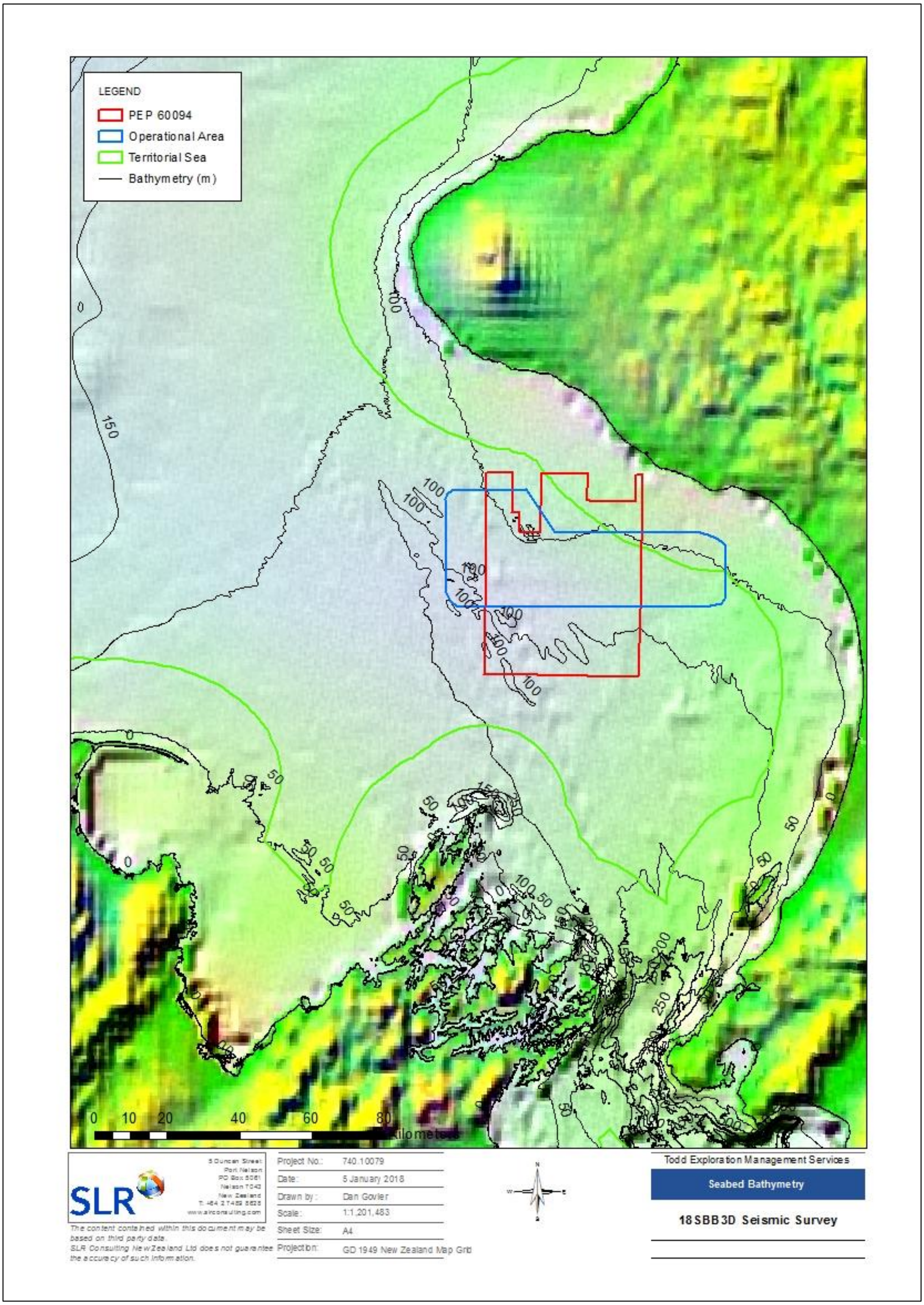
New Zealand is surrounded by a flat, gently sloping zone; the continental shelf. The shelf extends from the coast out to a water depth of 100 – 200 m. Beyond the continental shelf, the gradient of the seabed steepens and passes into the continental slope which descends relatively rapidly from the edge of the shelf down to depths in excess of 4,000 m. At the foot of the slope, the seaward gradient flattens out into the ocean basins which are a wide undulating but relatively flat zone lying at depths of 4,000 – 5,000 m.

The surface of the continental shelf is predominantly flat (punctuated by local banks and reefs), whereas the slope is irregular with large marine valleys (submarine canyons). These tend to occur in slope areas of relatively steep gradient (e.g. off Kaikoura) and generally run from the edge of the continental shelf to the foot of the continental slope. However, there are no submarine canyons in the vicinity of the Operational Area.

The width of New Zealand's continental shelf varies: the shelf is broad in the North Taranaki Bight, narrowing around Cape Egmont before widening again across the South Taranaki Bight (MacDiarmid et al., 2015). The Taranaki Continental Shelf has a 150 km wide opening to the Tasman Sea, occupying 30,000 km^2, and slopes gently towards the west with an overall gradient of <0.1° and locally less than 0.5° (Nodder, 1995).

The bathymetry of the Operational Area is shown in **Figure 8**. The seabed there has a low overall gradient, but features numerous undulations that are referred to locally as the 'rolling grounds' (McComb et al., 2004). There is little variation in water depth within the Operational Area; from 30 m in the shallows to a maximum depth of 100 m in the western part of the Operational Area. The inner continental shelf out to 50 m depth is about 40 km wide off Patea and narrows immediately south, as far as Whanganui, to about 20 km wide. The topography off Patea and Waitotara are characterised by banks, shoals and ridges (Hume et al., 2015).

Figure 8 Bathymetry of the Operational Area



There are eight sedimentary basins underlying New Zealand's continental shelf with known or potential hydrocarbons present (**Figure 9**). To date, commercial quantities of oil and gas have only been produced from the Taranaki Basin.

Figure 9 New Zealand's Sedimentary Basins

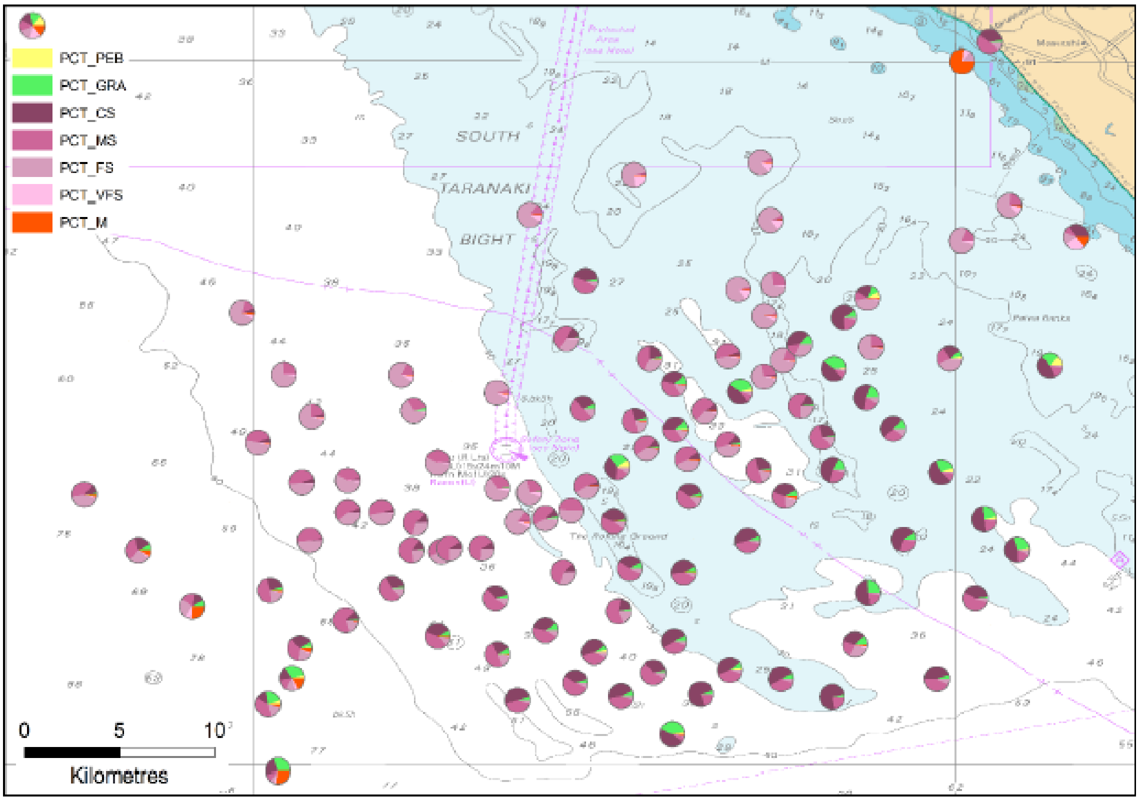
Source: NZP&M, 2013

The Operational Area traverses the Taranaki Basin which lies at the southern end of a rift that developed sub-parallel to the Tasman Sea rift and 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 structure of the basin is controlled by movements along the Taranaki, Cape Egmont and Turi fault zones. Jurassic to earliest Cretaceous Murihiku marine and non-marine rocks form basement of the earliest basin-fill (NZP&M, 2015).

Coastal basement rocks in the Taranaki Basin originate from a number of 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 terrane (Morton & Miller, 1968).

Surficial marine sediment across the Taranaki Shelf follows a gradient from the coastal zone to the continental shelf, with fine to medium sand typical of coastal sediments and silt and muds prevailing further offshore. West-southwest storm generated waves and currents are most likely the predominant sediment transport agents along the Taranaki coastline (MacDiarmid et al., 2015). The Operational Area is characterised by fine sand in the north and west, whereas the south and west areas have a greater proportion of coarse sand and gravel (**Figure 10**).

Figure 10 Grain Size of Seabed Sediments in the South Taranaki Bight around the Operational Area



Key: diagram shows percentages in different size classes for each location sampled. Pebbles (PEB), Gravel (GRA) Coarse sand, 500 µm – 1.6 mm (CS), Medium sand, 250 µm – 500 µm (MS), Fine sand, 125 µm – 250 µm (FS), Very fine sand, 63 µm – 125 µm (VFS), Mud <63 µm (M). From Hume et al. 2015)

5.2 Biological Environment

A description of marine mammal presence in the Operational Area provides a key focus for this section; however the state of the local environment in relation to other marine species and habitats is also provided to fully satisfy the requirements of the Code of Conduct (see **Section 3.5.2**).

5.2.1 Cetaceans

Understanding cetacean distribution is typically a process that occurs cumulatively over long temporal periods using a combination of different data collection techniques (stranding data, opportunistic sightings and systematic survey data if available). For this reason, it is important to consider multiple data sources to assess which cetacean species may be present within the Operational Area. Data sources used to populate this section of the MMIA include:

- Sightings data (from the DOC marine mammals sightings database which includes both sightings from past seismic surveys and opportunistic sightings from members of the public);
- Stranding data (from the DOC marine mammals strandings database);
- Published species accounts (i.e. information on ecology, distribution, migration paths and habitat preferences of each species); and
- Systematic data from aerial surveys over the Patea Shoals region (Cawthorn, 2013).

The Cawthorn (2013) study is of particular note as this represents the only systematic survey data for the Operational Area. Here a series of aerial surveys for the purpose of detecting marine mammals were undertaken by Trans-Tasman Resources over 26 months from 2011 in the vicinity of the Operational Area (Cawthorn, 2013). These aerial surveys covered the coastal area (out to 24.5 M) from Manaia in the northwest to between Patea and Waverly in the southeast, which overlaps with approximately 40% of the 18SBB3D seismic survey Operational Area. A line transect method was used and in total 4,550 M of transect was flown over the survey period. Cetaceans were only detected once throughout the survey period; when a small pod of common dolphins (6-10 individuals) were observed.

The four data sources listed above represent the best possible information. However, sighting data is strongly biased by observation effort which varies significantly around New Zealand, and stranding data should be considered in light of the fact that dead animals can wash ashore a long way from where they died; and that prior to death, unhealthy animals may be well outside their normal distributional range. **Figure 11** provides a summary of all sightings from the DOC marine mammal sightings database in the vicinity of the Operational Area, while **Figure 12** provides a summary of the DOC stranding records in the region. The guidelines used to assess the likelihood of a species being present in the Operational Area are presented in **Table 8**.

This section summarises the cetacean species which could be present in the Operational Area. In total, 48 cetacean species have been recorded in New Zealand waters (Baker et al., 2016). Of these, the following 11 species have been identified as being 'likely' to occur in the Operational Area:

- Bottlenose dolphin (nationally endangered);
- Common dolphin (not threatened);
- Cuvier's beaked whale (data deficient – presumed threatened);
- Dusky dolphin (not threatened);
- Dwarf minke whale (not threatened);
- False killer whale (not threatened);
- Gray's beaked whale (not threatened);
- Killer whale (nationally critical)

- Long-finned pilot whale (not threatened);
- Pygmy blue whale (migrant);
- Pygmy sperm whale (not threatened); and
- Sperm whale (not threatened).

For those species assessed as being 'likely', 'possible' or 'occassional visitors' to the Operational Area, a basic species account is provided in the subsections below and a summary of the assessment findings is provided in **Table 9.**

Table 8 Guidelines used to assess the likelihood of cetacean species being present

Likely	Species that are represented in the DOC sightings and/or stranding record from the Operational Area and which are not classified as 'Vagrant', or 'Data Deficient' in the New Zealand Threat Classification System (Baker et al., 2016).
Possible	Species that are represented in the DOC sightings and/or stranding record from the Operational Area and which are classified as 'Data Deficient' in the New Zealand Threat Classification System (Baker et al., 2016).
Occasional Visitor	Species that are represented in the DOC sightings and/or stranding record from the Operational Area, but are listed as 'Migrant' in the New Zealand Threat Classification System (Baker et al., 2016). Note that this criterion does not preclude some 'Migrant' species from being assessed as being 'likely' to occur in the Operational Area.
Rare Visitor	Species that are present in the DOC sightings and/or stranding record from the Operational Area, or reportedly occur in the Operational Area, or whose known range is directly adjacent to the Operational Area, but are listed as 'Vagrant' in the New Zealand Threat Classification System (Baker et al., 2016).
Unlikely	Those species not represented in the DOC sightings and/or stranding record from the Operational Area.
Note	*Where only very small numbers of sightings or strandings are present in the DOC Strandings and Sighting Databases, likelihood determination has been adjusted to take any additional information into consideration.*

Figure 11 Cetacean Sightings in the Vicinity of the Operational Area

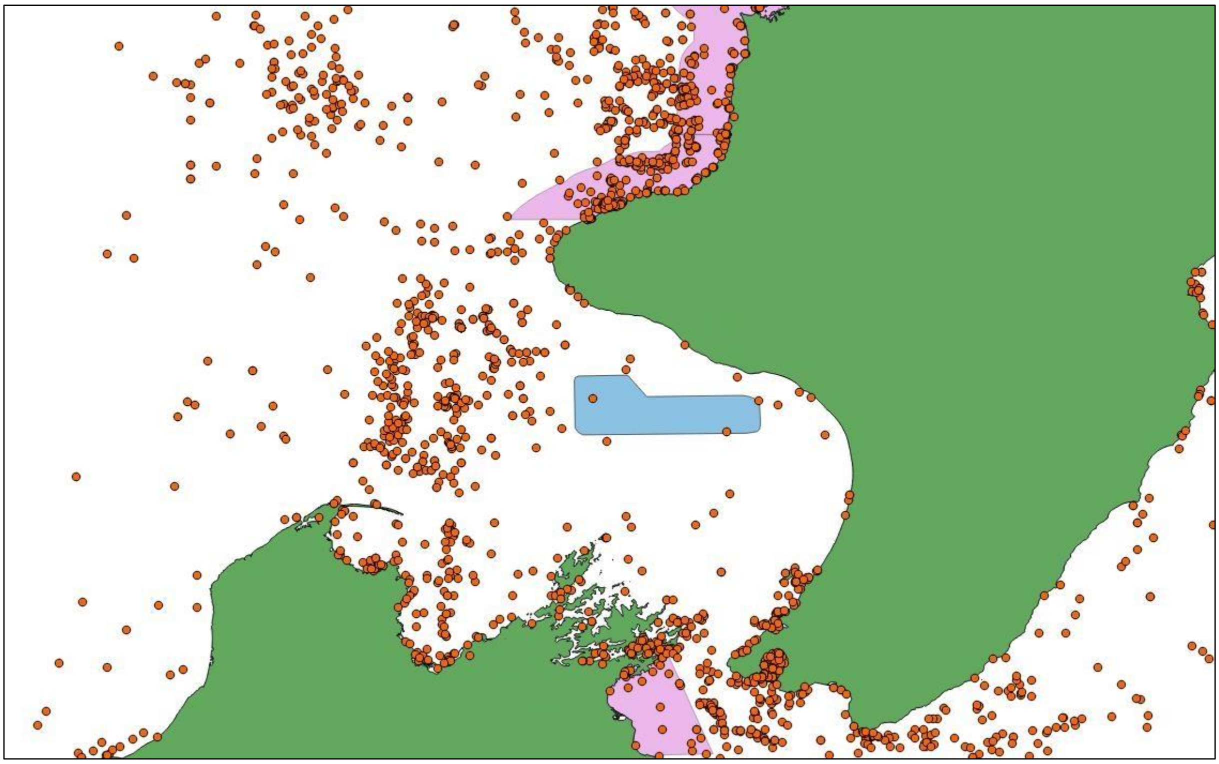


Figure 12 Cetacean Strandings in the Vicinity of the Operational Area

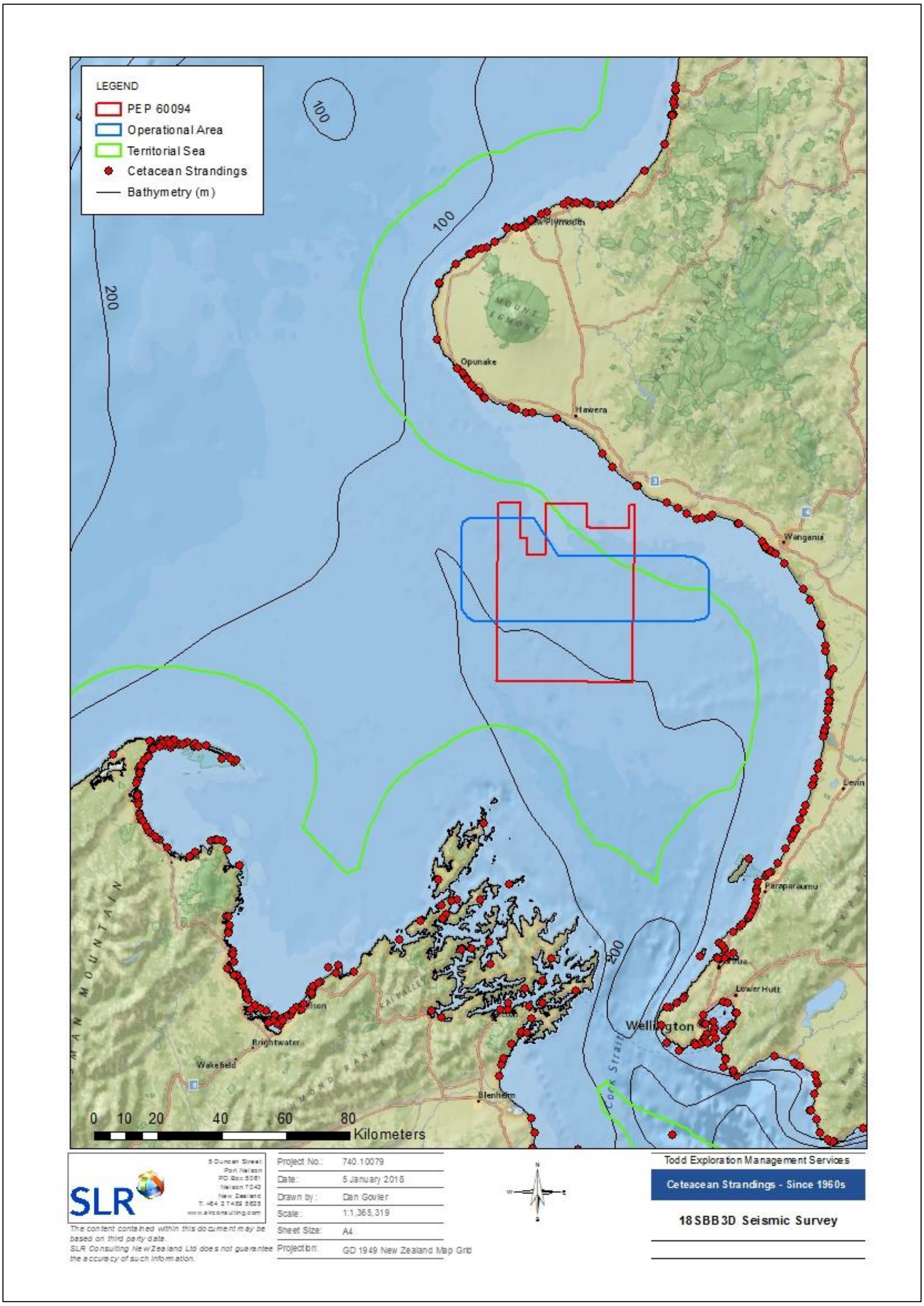


Table 9 Likelihood of Occurrence of Marine Mammals in the Operational Area. Note “data deficient” is presumed threatened in the NZ Conservation status classification system.

Common Name	**Scientific Name**	**NZ Conservation Status** (Baker *et al.*, 2016)	**Qualifier ***	**IUCN Conservation Status** www.redlist.org (July 2017)	**Species of Concern** (DOC, 2013)	**DOC Stranding database** (No. of events near Operational Area**)	**DOC Sightings database** (No. of reports in Operational Area)	**Presence in the Operational Area**
Andrew's beaked whale	*Mesoplodon bowdoini*	Data deficient	SO	Data deficient	Yes	✓ (2)	×	Possible
Antarctic blue whale	*Balaenoptera musculus intermedia*	Migrant	TO	Critically endangered	Yes	✓ (2)	✓ (****)	Occasional visitor
Antarctic fur seal	*Arctocephalus gazella*	Vagrant	SO	Least concern	No	×	×	Unlikely
Antarctic minke whale	*Balaenoptera bonaerensis*	Not threatened	DP, SO	Data deficient	Yes	×	×	Unlikely
Arnoux's beaked whale	*Berardius arnuxii*	Migrant	SO	Data deficient	Yes	✓ (5)	×	Occasional visitor
Blainville's/Dense beaked whale	*Mesoplodon densirostris*	Data deficient	SO	Data deficient	Yes	×	×	Unlikely
Bottlenose dolphin	*Tursiops truncatus*	Nationally endangered	CD, Sp, SO	Least concern	Yes	✓ (2)	×	**Likely**
Bryde's whale	*Balaenoptera edeni*	Nationally critical	SO	Data deficient	Yes	✓ (1)	×	Possible ***
Common dolphin	*Delphinus delphis*	Not threatened	DP,SO	Least concern	No	✓ (9)	✓ (1)	**Likely**
Crab eater seal	*Lobodon carcinophaga*	Vagrant	SO	Least concern	No	×	×	Unlikely
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	SO	Least concern	Yes	✓ (11)	×	**Likely *****
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	SO	Data deficient	No	✓ (5)	×	**Likely**
Dwarf minke whale	*Balaenoptera acutorostrata*	Not threatened	DP, SO	Least concern	Yes	✓ (3)	×	**Likely**
Dwarf sperm whale	*Kogia sima*	Vagrant	SO	Data deficient	Yes	×	×	Unlikely
False killer whale	*Pseudorca crassidens*	Not threatened	DP, SO	Data deficient	Yes	✓ (2)	×	**Likely**
Fin whale	*Balaenoptera physalus*	Migrant	TO	Endangered	Yes	✓ (1)	×	Occasional visitor
Fraser's dolphin	*Lagenodelphis hosei*	Vagrant	SO	Least concern	No	×	×	Unlikely
Gingko-toothed whale	*Mesoplodon ginkgodens*	Vagrant	SO	Data deficient	Yes	×	×	Unlikely
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	DP, SO	Data deficient	Yes	✓ (15)	×	**Likely**
Hector's beaked whale	*Mesoplodon hectori*	Data deficient	SO	Data deficient	Yes	×	×	Unlikely ***
Hector's dolphin	*Cephalorhynchus hectori hectori*	Nationally endangered	CD	Endangered	Yes	✓ (1)	×	Possible ***
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	SO	Least concern	No	×	×	Unlikely
Humpback whale	*Megaptera novaeangliae*	Migrant	SO	Least concern	Yes	×	×	Possible ***
Killer whale	*Orcinus orca*	Nationally critical	DP, SO, Sp	Data deficient	Yes	×	×	Possible ***
Leopard seal	*Hydrurga leptonyx*	Vagrant	SO	Least concern	No	×	×	Unlikely
Lesser/pygmy beaked whale	*Mesoplodon peruvianus*	Vagrant	SO	Data deficient	Yes	×	×	Unlikely
Long-finned pilot whale	*Globicephala melas*	Not threatened	DP, SO	Data deficient	Yes	✓ (14)	×	**Likely**
Maui's dolphin	*Cephalorhynchus hectori maui*	Nationally critical	CD	Critically Endangered	Yes	✓ (3)	×	Possible ***
Melon-headed whale	*Peponocephala electra*	Vagrant	SO	Least concern	Yes	×	×	Unlikely
New Zealand sea lion	*Phocarctos hookeri*	Nationally critical	RR	Endangered	Yes	×	×	Unlikely
New Zealand fur seal	*Arctocephalus forsteri*	Not threatened	Inc, SO	Least concern	No	×	✓ (many)	**Likely**
Pantropical spotted dolphin	*Stenella attenuata*	Vagrant	SO	Least concern	No	×	×	Unlikely
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Migrant	SO	Data deficient	Yes	✓ (2)	✓ (****)	**Likely *****

Common Name	**Scientific Name**	**NZ Conservation Status** (Baker *et al.*, 2016)	**Qualifier ***	**IUCN Conservation Status** www.redlist.org (July 2017)	**Species of Concern** (DOC, 2013)	**DOC Stranding database** (No. of events near Operational Area**)	**DOC Sightings database** (No. of reports in Operational Area)	**Presence in the Operational Area**
Pygmy killer whale	*Feresa attenuata*	Vagrant	DP, SO	Data deficient	Yes	×	×	Unlikely
Pygmy right whale	*Caperea marginata*	Data deficient	SO	Data deficient	Yes	✓ (1)	×	Possible
Pygmy sperm whale	*Kogia breviceps*	Not threatened	DP, SO	Data deficient	Yes	✓ (13)	×	**Likely**
Risso's dolphin	*Grampus griseus*	Vagrant	SO	Least concern	No	✓ (2)	×	Rare visitor
Ross seal	*Ommatophoca rossii*	Vagrant	SO	Least concern	No	×	×	Unlikely
Rough-toothed dolphin	*Steno bredanensis*	Vagrant	SO	Least concern	No	×	×	Unlikely
Sei whale	*Balaenoptera borealis*	Migrant	TO	Endangered	Yes	×	×	Unlikely
Shepherd's beaked whale	*Tasmacetus shepherdi*	Data deficient	SO	Data deficient	Yes	✓ (3)	×	Possible
Short-finned pilot whale	*Globicephala macrorhynchus*	Migrant	SO	Data deficient	Yes	×	×	Unlikely
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	SO	Least concern	Yes	✓ (1)	×	Possible
Southern elephant seal	*Mirounga leonina*	Nationally critical	RR, SO	Least concern	No	×	×	Unlikely
Southern right whale	*Eubalaena australis*	Nationally vulnerable	RR, SO	Least concern	Yes	×	×	Possible ***
Southern right whale dolphin	*Lissodelphis peronii*	Not threatened	DP,SO	Data deficient	Yes	×	×	Unlikely
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	SO	Data deficient	No	×	×	Unlikely
Spectacled porpoise	*Phocoena dioptrica*	Data deficient	SO	Data deficient	No	×	×	Unlikely
Sperm whale	*Physeter macrocephalus*	Not threatened	DP, TO	Vulnerable	Yes	✓ (10)	×	**Likely**
Strap-toothed whale	*Mesoplodon layardii*	Data deficient	SO	Data deficient	Yes	✓ (5)	×	Possible
Striped dolphin	*Stenella coeruleoalba*	Vagrant	SO	Least concern	No	✓ (1)	×	Rare visitor
Subantarctic fur seal	*Arctocephalus tropicalis*	Vagrant	SO	Least concern	No	×	×	Unlikely
True's beaked whale	*Mesoplodon mirus*	Data deficient	SO	Data deficient	Yes	×	×	Unlikely
Weddell seal	*Leptonychotes weddellii*	Vagrant	SO	Least concern	No	×	×	Unlikely

** Qualifiers to the New Zealand Threat Classification System are as follows: Secure Overseas (SO), Threatened Overseas (TO), Data Poor (DP), Conservation Dependent (CD), Sparse (Sp), Range Restricted (RR), Increasing (Inc)*

*** Stranding data from the following locations was deemed to be 'near the Operational Area': South Taranaki, Whanganui/Manawatu.*

**** Likelihood determination has been adjusted to take into consideration information in addition to the DOC Strandings and Sighting Databases.*

***** The number of sightings of blue whales is difficult to interpret as the DOC Sighting Database records most sightings as Balaenoptera musculus (i.e. without subspecies identification). In total the data base holds 2 sighting records for Balaenoptera musculus spp in the Operational Area. Based on the recent findings of Torres et al. (2017), it is likely that the majority of these sightings are of Balaenoptera musculus brevicauda (pygmy blue whales).*

Baleen whales

Most species of baleen whale in the southern hemisphere are migratory and travel south in spring to feed in Antarctic waters over summer and return northwards to temperate and tropical breeding grounds in autumn-winter (DOC, 2007). Exceptions to this are Bryde's whales and pygmy blue whales (further discussed in **Section 5.2.1.4** and **Section 5.2.1.1** respectively) which do not exhibit clear migratory patterns and instead are resident or semi-resident to preferred habitats throughout the year. Large numbers of blue whales have been sighted in the South Taranaki Bight throughout most of the year, with infrequent sightings occurring within and in the vicinity of the Operational Area.

It is noteworthy that the 18SBB3D seismic survey will take place during the late summer/early autumn of 2018. At this time of the year most species of baleen whale will still be at the Antarctic feeding grounds and it is anticipated that the survey will be complete well before the northward migration gets underway in late autumn/winter. It is therefore unlikely that the 18SBB3D seismic survey will overlap temporally with baleen whale migrations.

5.2.1.1 Blue whale

Of the two subspecies of blue whale known from New Zealand waters (Antarctic blue whales and pygmy blue whales); the pygmy blue whale is of greatest relevance to this MMIA on account of a population of resident or semi-resident pygmy blue whales being present in the South Taranaki Bight throughout most months of the year (Torres et al., 2017).

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). The South Taranaki Bight has been identified as important feeding habitat for pygmy blue whales which feed on dense concentrations of the krill species *Nyctiphanes australis*. The absolute distribution of whales here varies with krill distribution which is positvively associated with the occurrence of oceanographic upwellings in the Bight. During El Nino conditions whales tend to be located west of the Bight, but are more commonly found inside the Bight at other times (Torres & Klinck 2016). However, data presented in Torres et al. (2017) indicate that during non El Nino years most blue whale sightings in the South Taranaki Bight occur well to the south-west of the Operational Area. Blue whales capture krill both at the surface (lunge feeding) and at depth (down to 100 m) where feeding bouts typically last 10-20 minutes, and up to 50 minutes (Todd, 2014). Blue whales have the highest prey demand of any predator (Rice, 1978; DOC, 2007); hence large prey aggregations are critical to this species.

In addition to providing feeding habitat, breeding behaviour has also been documented in and around the South Taranaki Bight; with high densities of mother/calf pairs being observed during February 2016 and the first ever aerial footage of blue whale nursing behaviour also being collected during this research expedition (Torres & Klinck, 2016).

Individual whales using the South Taranaki Bight display a genetically distinct haplotype compared to pygmy blue whale populations elsewhere in Australasia. This suggests that the whales here comprise a genetically unique population. The New Zealand Threat Classification System currently classifies both subspecies of blue whales as "Migrant"; however, in light of the new evidence for pygmy blue whale breeding behaviour in the South Taranaki Bight, it is possible that this classification will change in the future.

Blue whales (both subspecies) have been detected acoustically throughout New Zealand waters (Olsen et al., 2013; Miller et al., 2014), with acoustic detection most common on the west coast of the North Island, and the east coast of the South Island. Blue whales vocalise at a low frequency (average of 0.01 – 0.110 kHz) (McDonald et al., 2001; Miller et al., 2014), meaning that their calls travel hundreds of kilometres underwater. The amplitude of their calls can reach levels of up to 188 dB re 1ɥPa m^{-1} (Aroyan et al., 2000; Cummings & Thompson, 1971).

Despite most blue whale sightings in the South Taranaki Bight occuring to the south-west of the Operational Area (Torres et al., 2017), the DOC database includes one record of a blue whale sighting (of a group of three animals) from within the Operational Area. Four stranding events for blue whales (both subspecies) have occurred from coastal areas in the vicinity of the Operational Area (both in both South Taranaki and Whanganui/Manawatu). It is also noteworthy that blue whales have frequently been seen during another recent seismic survey in Taranaki waters; and some sightings have been made in close proximity to the Operational Area (D. Lundquist, pers. comm.). Based on this assessment it is likely that blue whales (particularly pygmy blue whales) will be present in the Operational Area.

5.2.1.2 Minke whale

Two species of minke whale occur in New Zealand waters; the Antarctic minke whale and the dwarf minke whales. Antarctic minkes are restricted to the southern hemisphere where they are very abundant in Antarctic waters over the summer months, but are seen at lower latitudes in other seasons (Reilly et al., 2008). The dwarf minke occurs in both the northern and southern hemispheres, where in the southern hemisphere, it shares a similar distributional pattern to the Antarctic minke; feeding near Antarctica during summer and ranging further afield in other seasons (Reilly et al., 2008). Dwarf minkes occur in shallower coastal water over the continental shelf outside of summer (Jefferson et al., 2008; Perrin, 2009). Minke whale diet appears to vary geographically, and there is a relative paucity of information about feeding habits and diet of dwarf minke whales (IUCN, 2017). Communication calls produced by minke whales are complex and typically fall within the 50 Hz – 9.4 kHz frequency range (DOSITS, 2017).

A brief analysis of the DOC sighting data indicates that the distribution of minke whales around New Zealand extends around both the mainland and throughout the subantarctic, with the majority of sightings occurring in spring. These sightings presumably represent animals on their southern migration towards the Antarctic feeding grounds.

No minke whale sightings have been made within the Operational Area; however, three stranding events have been reported (all dwarf minkes). Strandings have occurred in both South Taranaki and Whanganui/Manawatu. Based on this assessment it is likely that dwarf minke whales will be present in the Operational Area; however sightings are more common from the South Taranaki Bight in spring.

5.2.1.3 Humpback whale

Like most baleen whales, humpback whales feed in Antarctic waters during summer and travel north to tropical waters where they breed in winter. Humpback whales that migrate through New Zealand waters have links to breeding grounds in New Caledonia, Fiji and Tonga (as summarised by Gibbs et al, 2017). Migratory behaviour around New Zealand is evident as whales travelling northwards up the east coast of New Zealand, with some passing through Cook Strait from May to August; while others continue up the east coast of the North Island (Gibbs & Childerhouse, 2000). Less is known about the southward migration routes; but it appears that some whales travel down the west coast of New Zealand (Dawbin, 1956), while others travel well off the east coast of New Zealand from September to December (NZGeo.com, 2016). 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 from 2004 – 2015. Over the 12 year survey 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) (DOC, 2015). Over the survey period there was a significant increase in the daily average number of whales sighted (from 1 to 6 whales per day), but this increase was only apparent from 2015 (Gibbs et al., 2017). From this data the calculated rate of increase was 13% (5-22%, 95% Confidence Interval), suggesting the beginning of population recovery.

Humpback whales produce communication calls, with males being particularly reknowned for generating long, complex 'songs' during the breeding season. These songs typically last from 10 to 20 minutes (American Cetacean Society, 2014) and tend to be between 0.03–8 kHz in frequency (Simmonds et al., 2004).

No humpback whale sightings have been reported within the Operational Area; neither have there been any strandings inshore of the Operational Area. However, occassional sightings of humpback whales have been made in coastal Taranaki waters, particularly between the months of May and August during the northern migration. Previous seismic surveys have documented sightings of humpback whales within the Taranaki region; therefore it is possible that this species could sometimes occur in the Operational Area (particularly during the winter months).

5.2.1.4 Bryde's whale

New Zealand Bryde's whales are mainly found around the North Island, where a subpopulation is routinely present in the Hauraki Gulf (Baker et al., 2010). Systematic surveys here and along the east coast of Northland, have confirmed that the Hauraki Gulf is as a regionally important breeding area (Baker & Madon 2007; Wiseman et al., 2011). Bryde's whales are occasionally seen in other regions around the North Island, including Taranaki (Torres, 2012).

Globally, Bryde's whales typically inhabit tropical and warm temperate waters between 40°N and 40°S (as summarised in Riekkola, 2013), and unlike other baleen whales, this species does not undertake seasonal long-distance migrations (Kato, 2002).

Oleson et al. (2003) analysed Bryde's whale calls from a number of regions around the Pacific Ocean. Sime regional variation was present; however overall the calls were low frequency, with fundamental frequencies being 60 Hz.

No Bryde's whale sightings have occurred within the Operational Area, but one stranding event is recorded in the vicinity (Foxton Beach). The Operational Area is nearly at the southern latitudinal limit for this species; hence, it is possible that Bryde's whales could be present from time to time in the Operational Area.

5.2.1.5 Fin whale

Fin whales have a global distribution in offshore waters (Reilly et al., 2013), and like other baleen whales, they migrate between high latitude feeding grounds in summer and lower latitude breeding grounds in winter (Miyashita et al., 1995). Krill dominates the diet of fin whales in the southern hemisphere (Miyashita et al., 1995; Shirihai & Jarrett, 2006). Torres (2012) suggested that fin whales, like pygmy blue whales, might also feed on krill aggregations in the South Taranaki Bight; however, sighting records don't corroborate this hypothesis.

Communication vocalisations for this species have been described as short (<1 second) down-swept tones, ranging from 28 to 25 Hz at source levels of 189 +/-4dB re 1ɥPa m-1 (Širović et al., 2004).

No fin whale sightings have been made in the Operational Area, but one stranding has been reported from nearby Ohawe Beach. Based on this assessment, fin whales are considered as occasional visitors to the Operational Area.

5.2.1.6 Southern right whale

Southern right whales exhibit distinct seasonal migrations, skim feeding on aggregations of copepods and euphausiids during summer months at high latitudes (Braham & Rice, 1984; Tormosov et al., 1998; Rowantree et al., 2008). Outside of the summer months, New Zealand southern right whales range between two winter breeding grounds; the Auckland Islands and mainland New Zealand.

Southern right whales are the only baleen whale species to calve in New Zealand waters; where coastal waters of mainland New Zealand represent a historic winter calving ground for this species. Recent evidence suggests that a slow recolonisation of the mainland breeding range is currently occurring (Patenaude, 2003; Carroll et al., 2011). The majority of southern right whale sightings around the New Zealand mainland occur in winter (60%) and spring (22%) with nearly all sightings occurring close to the coast (Patenaude, 2003). Whilst some calves are born around the mainland, Port Ross in the subantarctic Auckland Islands is the principal calving area for the New Zealand population (Rayment et al., 2012).

Following the cessation of historic whaling, southern right whales around New Zealand are now making a recovery. Pre-exploitation abundance of southern right whales here was estimated to have been between 28,800 and 47,100 individuals, but was reduced to only 30–40 mature females at the time that whaling ceased (Jackson et al., 2016). Numbers of this species around New Zealand now are currently thought to represent approximately 12% of pre-exploitation abundance (Jackson et al., 2016).

Vocalisations of New Zealand southern right whales have been classified into ten call types; with 'pulsive', 'upcalls' and 'tonal low' vocalisations being the most frequently recorded (Webster et al., 2016). Peak frequencies of all the call types ranged from 110 to 795 Hz (Webster et al., 2016).

No sightings of this species have been made from the Operational Area and neither have any strandings been reported inshore of the area. However, it is important to note that this species seldom strands on account of it being very comfortable in the shallow coastal waters that comprise its winter breeding habitat. Despite its absence from the sighting record within the Operational Area, this species is not infrequently seen along the west coast of the lower North Island; therefore it is possible that southern right whales could have a presence in the Operational Area; with the majority of coastal sightings expected during winter.

5.2.1.7 Pygmy right whale

Distributional information for this species is relatively scant as few live sightings have been made (Reilly et al., 2008a). However, Kemper (2013) suggests an association between pygmy right whales and areas of high marine productivity. In Australasia, this species is thought to occur between 32 and 47 °S, with young calves recorded in waters from 35 – 47 °S (Kemper, 2002). In New Zealand, sightings typically occur near Stewart Island and Cook Strait (Kemper, 2002), with a group of 14 pygmy right whales being seen at 46°S southeast of New Zealand in 2001 (Matsuoka et al*.,* 2005). The diet of this species consists largely of copepods (Reilly et al., 2008a) and euphausiids (Kemper, 2002) which are common in the waters off South Taranaki.

Pygmy right whales are the smallest of the baleen whales, growing to only 6.4 m long (Baker, 1999). With regard to vocalisations, recordings of a juvenile pygmy right whale from Australia revealed a short thump-like pulse with a down-sweep in frequency and decaying amplitude (Dawbin & Cato, 1992).

Although no sightings of pygmy right whales have been recorded in the Operational Area, one stranding has been reported from near the Operational Area (Whanganui). This stranding record suggests that pygmy right whales could possibly be present in the Operational Area.

Toothed whales

5.2.1.8 Sperm whale

Sperm whales are usually found in open ocean waters deeper than 1,000 m and have a wide geographical and latitudinal distribution. In New Zealand waters, the Kaikoura region is home to a small number of semi-resident male sperm whales that feed in the submarine canyons and are present year round within a few kilometres of the shore (Jaquet et al., 2000). Groups of females have only occasionally been seen off Kaikoura (Richter et al., 2003). Sperm whales occur offshore right around New Zealand, including Taranaki where sightings are typically made in deep offshore water during the summer months (Torres, 2012).

Sperm whales forage primarily for squid, and dives can last over an hour (Evans & Hindell, 2004; Gaskin & Cawthorn, 1967; Gomez-Villota, 2007) and reach depths of up to 3,000 m. This species is reliant on echolocation to locate prey and for navigation. Echolocation clicks are also produced as a means of communication, to identify members of a group and to coordinate foraging activities (Andre & Kamminga, 2000). Clicks are varied in frequency, ranging from low-frequency clicks (0.1 kHz) to high-frequency clicks (up to 30 kHz) (Simmonds et al., 2004).

No sperm whale sightings have been reported from the Operational Area, but ten strandings have occurred nearby; the majority in South Taranaki. Previous seismic surveys have documented sightings of sperm whales in the wider Taranaki region, however potential for sperm whale sightings during the 18SBB3D Seismic Survey is reduced on account of the comparatively shallow water depths of the Operational Area. Based on this assessment, sperm whales are likely to be present in the Operational Area.

5.2.1.9 Pygmy sperm whale

Little information is available on this species, as pygmy sperm whales maintain a low profile on the water surface and lack of a visible blow hence are seldom seen at sea. The diet of pygmy sperm whales consists of cephalopods, fish and occasionally crustaceans (Shirihai & Jarrett, 2006). The acoustic repertoire of this species is not well known, but recordings from live stranded animals indicate that the species emits click trains between 60 kHz and 200 kHz (Marten, 2000).

Despite no live sightings being recorded for the Operational Area, 13 strandings have been reported near the Operational Area (from both South Taranaki and Whanganui/Manawatu). Based on this assessment, pygmy sperm whales are likely to occur in the Operational Area.

5.2.1.10 Pilot whale

The long-finned pilot whale and the short-finned pilot whale are both present in New Zealand waters; however the short-finned pilot whale is less frequently encountered here as it prefers warmer subtropical water temperatures. Pilot whales often travel in large groups of over 100 individuals and feed on fish and squid in deep water along shelf breaks. New Zealand pilot whales predominantly feed on cephalopods; usually arrow squid and common octopus (Beatson et al., 2007).

Pilot 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, where data from 1937 to 2017 revealed that at least 30 mass stranding events occurred during this period; the largest of which involved approximately 416 individual whales. November, December and January were the most common months in which mass strandings occurred, and long-finned pilot whales accounted for virtually all (29) of these stranding events.

Sightings of pilot whales in Taranaki waters are reasonably common with most occurring in summer (Torres, 2012). One sighting of pilot whales exists for the Operational Area (a group of two animals). Fourteen strandings have occurred in the vicinity (all involving long-finned pilot whales). The majority of strandings occurred in Whanganui/Manawatu. Based on this assessment it is likely that long-finned pilot whales will be encountered in the Operational Area; however recent sightings of short-finned pilot whales from another seismic survey in Taranaki waters (D. Lundquist, pers. comm.) indicate that this species may also be present from time to time.

5.2.1.11 Killer whale

Of the four morphological forms of killer whales (Types A – D) (Baker et al., 2010), the majority of sightings in New Zealand are of Type A individuals which have been recorded in all coastal regions (Visser, 2000; Visser, 2007). In New Zealand killer whales typically travel in small groups and cover an average of 100 – 150 km per day (Visser, 2000). The mobility of this species and their opportunistic foraging behaviour (Visser, 2000) indicates that killer whales can readily move between areas to maximise foraging opportunities and avoid disturbance. The only population estimate for killer whales in New Zealand suggested that 115 individuals (95% CI 65–167) were present in 1997 (Visser, 2000).

Echolocation characteristics vary between groups of killer whales, and are thought to reflect the target prey species of a particular group (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).

Our assessment of the sighting and stranding data found no live sightings of this species in the Operational Area and no strandings in the immediate vicinity. However, killer whales are commonly seen in the South Taranaki Bight (Torres, 2012). Visser (2000) analysed opportunistic sighting data to suggest that this species is more frequently seen in the region from November to February; although Torres (2012) found sightings to be relatively evenly distributed through time. Based on this assessment, it is possible that killer whales could be present in the Operational Area during the proposed seismic operations.

5.2.1.12 False killer whale

Globally false killer whales are relatively common in warm temperate waters (Baird, 2002). In New Zealand, this species has an interesting habit of making close associations with bottlenose dolphins in shallow warm waters to the north-east of the North Island between December and May (Zaeschmaer et al., 2013). False killer whales forage at depths of up to 500 m and prey on fish and cephalopods (Shirihai & Jarrett, 2006).

No sightings of false killer whales have been reported in the Operational Area, but two strandings have been reported: one each in South Taranaki and Whanganui/Manawatu. On the basis of this assessment, this species is likely to be present in the Operational Area, particularly over the summer months when sea surface temperatures are warmer.

5.2.1.13 Beaked whales

Despite New Zealand being regarded as a hotspot for beaked whales, with 13 species having been reported here (Baker et al., 2016); little is known about the fine scale distribution of each species around New Zealand (Baker, 1999). Beaked whales are mostly found in small groups in cool, temperate waters with a preference for pelagic deep ocean waters or continental slope habitats at depths down to 3,000 m (Baker, 1999). Typically beaked whales are understood to be deep divers that feed predominately on deep-water squid and fish species (Pitman, 2002).

No live sightings of beaked whales have been made from the Operational Area. The majority of knowledge about beaked whales comes from stranded individuals and **Table 10** outlines the species that have stranded near the Operational Area and provides a brief account of the ecology of each of these species. From the assessment provided in **Table 10**, the following conclusions can be drawn:

- Two species (Gray's beaked whale and Cuvier's beaked whale) are likely to be present in the Operational Area;
- Four species (Andrew's beaked whale, Strap-toothed whale, Southern bottlenose whale and Shepherd's beaked whale) could possibly be present in the Operational Area;
- One species (Arnoux's beaked whale) could occasionally visit the Operational Area; and
- Six species (Blainville's/Dense beaked whale, Gingko-toothed whale, Hector's beaked whale, Lesser/pygmy beaked whale, True's beaked whale, Spade-toothed whale) are unlikely to occur in the Operational Area.

Table 10 Beaked Whale Ecology of Relevance to the Operational Area

Species	No. of stranding events near Operational Area	Ecology
Arnoux's beaked whale *(Berardius arnuxii)*	Whanganui/Manawatu x 4 South Taranaki x 1 **TOTAL = 5** (since 1920)	Circumpolar distribution in deep, cold temperate and subpolar waters. Considered to be naturally rare throughout its range; however, higher densities may occur seasonally in Cook Strait (Taylor et al., 2008). New Zealand has the highest number of strandings recorded for this species (Jefferson et al., 1993).
Andrew's beaked whale *(Mesoplodon bowdoini)*	Whanganui/Manawatu x 1 South Taranaki x 1 **TOTAL = 2** (since 1930)	Found between 32°S and 55°S in the southern hemisphere. Presumed to inhabit deep, offshore waters (Pitman, 2002). Based on the global stranding record, New Zealand might represent an area of concentration (Taylor et al., 2008a).
Gray's beaked whale *(Mesoplodon grayi)*	Whanganui/Manawatu x 8 South Taranaki x 7 **TOTAL = 15** (since 1931)	Southern hemisphere species with a circumpolar distribution south of 30°. Many sightings from Antarctic and subantarctic waters. Many strandings from coastline of New Zealand implying they may be fairly common here. Occurs in deep waters beyond the shelf edge (Taylor et al., 2008c). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).
Strap-toothed whale *(Mesoplodon layardii)*	Whanganui/Manawatu x 2 South Taranaki x 3 **TOTAL = 5** (since 1934)	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. (Taylor et al., 2008d). Feed on squid (Sekiguchi et al., 1996). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).
Southern bottlenose whale *(Hyperoodon planifrons)*	Whanganui/Manawatu x 1 **TOTAL = 1** (in 2011)	Circumpolar distribution in southern hemisphere, south of 30°. Common in Antarctic waters in summer. Typically occurs over submarine canyons in waters deeper than 1,000 m (Taylor et al., 2008e).
Shepherd's beaked whale *(Tasmacetus shepherdi)*	Whanganui/Manawatu x 1 South Taranaki x 2 **TOTAL = 3** (since 1933)	A circumpolar distribution in cold temperate waters is presumed. All strandings 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 (Taylor et al., 2008f).
Cuvier's beaked whale *(Ziphius cavirostris)*	Whanganui/Manawatu x 8 South Taranaki x 3 **TOTAL = 11** (since 1932)	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 (Taylor et al., 2008g). Genetic studies suggest little movement of individuals between ocean basins (Dalebout et al., 2005). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).

5.2.1.14 Bottlenose dolphin

New Zealand is the southernmost extent of the latitudinal range for bottlenose dolphins which occur throughout the world in cold temperate and tropical seas. The New Zealand population consists of an 'offshore' population of at least 163 individuals which occurs in offshore waters right around New Zealand (Zaeschmar et al., 2013), and four genetically distinct 'in-shore' populations: where c. 450 individuals occur off the northeast coast of Northland (Baker et al, 2010), c. 60 individuals occur in Fiordland (Baker et al, 2010), an unquantified population occurs in the coastal waters between the Marlborough Sounds and the West Coast (Baker et al, 2010), and c. 92 individuals that form a wide-ranging southern population around Otago and Stewart Island (Brough et al., 2015).

Sightings records suggest that offshore dolphins typically form larger groups than their inshore counterparts (Torres, 2012). Torres (2012) documented two sightings of offshore bottlenose dolphins in the South Taranaki Bight; these sightings both involved groups of more than 50 individuals; whereas inshore dolphins tend to travel in maximum groups of 30, but often group size is much smaller (Baker, 1999). Bottlenose dolphins feed on fish, krill and crustaceans (Shirihai & Jarrett, 2006) and produce echolocation 'clicks' during foraging (0.8-24 kHz). 'Whistles' are also produced and are used as a form of communication between individuals (40 – 130 kHz).

No live sightings of bottlenose dolphins have been reported for the Operational Area, but two strandings have been recorded in the vicinity (one each in South Taranaki and Whanganui/Manawatu). Based on this assessment, bottlenose dolphins are likely to occur in the Operational Area.

5.2.1.15 Common dolphin

The common dolphin ranges widely over the continental shelf and occurs in all regions of New Zealand (Berkenbusch et al., 2013). They occur in water depths ranging from 6 – 141 m (Constantine & Baker, 1997), and their diet consists primarily of jack mackerel, anchovy and arrow squid (Meynier et al., 2008). Diurnal off-shore/on-shore movements may occur in some locations based on patterns of prey distribution (Neumann, 2001; Meynier et al., 2008).

While no New Zealand population estimate is available, this species is regarded as one of the most abundant cetacean species. Common dolphins are highly social and often form large groups that include thousands of individuals. Torres (2012) conducted an assessment of cetacean sighting data for the South Taranaki Bight and concluded that common dolphins were the most frequently encountered cetacean species with most sightings being reported in summer (which may reflect a seasonal observational bias).

A wide repertoire of vocalisations is used by this species including echolocation click trains (during foraging), whistles and burst pulse calls (for communication). Whistle characteristics of common dolphins in the Hauraki Gulf have an average frequency of 10 – 14 kHz and length of 0.27 seconds (Petrella et al., 2012).

Systematic surveys of the Patea Shoals region from 2011 to 2013 only detected one small pod of common dolphins (6-10 individuals) over a total of 4,550 M of line transect (Cawthorn, 2013).

The DOC sighting database includes one sighting record for common dolphins in the Operational Area (one sighting of a solitary individual); however other common dolphin sightings occur nearby (including a group of 20 individuals). Strandings of this species are also relatively common from the vicinity of the Operational Area, with a total of nine reported (seven in Whanganui/Manawatu and two in South Taranaki). Based on this assessment, common dolphins are likely to be present in the Operational Area.

5.2.1.16 Dusky dolphin

Dusky dolphins typically occur in water depths less than 2,000 m above the continental shelf and slope and are present year round in New Zealand waters (Berkenbusch et al., 2013). They prefer cool, upwelling waters and are more commonly seen around the South Island and lower North Island where photo-identification data confirms that individuals routinely travel up to 1,000 km between locations (Wursig et al. 2007).

Dusky dolphins generally forage in relatively shallow waters, but can feed in waters up to 130 m deep where they feed on a range of pelagic and benthic prey including southern anchovy, squid, hake and lantern fishes (Hammond et al., 2008). This species spends more time in offshore waters during the winter months which could reflect prey duistribution (Wursig et al., 2007). There is a resident dusky dolphin population in Admiralty Bay (Marlborough Sounds) from April to July (Wursig et al., 2007). There is also a substantial population in the Kaikoura area, which has been estimated at 12,000 individuals, with approximately 2,000 individuals present at any one time (Markowitz et al., 2004).

Dusky dolphins produce click trains, burst pulses and whistles; with burst pulses being the predominant call type (Yin, 1999). The echolocation signals for this species are broadband with a bimodal frequency spectra peaking between 40-50 kHz and 80-110 kHz (Au & Wursig, 2004).

No sightings of dusky dolphins have occurred in the Operational Area, but five strandings have occurred in the vicinity (all in the Whanganui/Manawatu region). On the basis of this assessment, dusky dolphins are likely to be present in the Operational Area.

5.2.1.17 Hector's dolphins

There are two subspecies of Hector's dolphin; the South Island Hector's dolphin and the Maui's dolphin. In general, the two subspecies are genetically and geographically distinct with Maui's dolphins occurring along the west coast of the North Island, and South Island Hector's dolphins occurring around the South Island. In a small number of instances, South Island Hector's dolphins have been genetically identified off the west coast of the North Island (Hamner et al., 2012; Baker et al., 2016a), confirming that some individuals of both subspecies do occassioanlly overlap spatially. With regards to visual detections at sea, the two subspecies are morphologically identical and can only be distinguished genetically.

Both subspecies have coastal distributions and are typically reported in waters shallower than 100 m (Slooten et al., 2006; Du Fresne, 2010). Maui's dolphins have been observed out to 12 M offshore during research surveys (DOC, 2017) and South Island Hector's dolphins out to 20 M offshore (MacKenzie & Clement, 2014). Sigthings of both subspecies out to 24 M (Du Fresne, 2010) have been reported, with offshore sightings more common in winter. The diet of both subspecies is comprised of small fish and crustaceans, where echolocation (with frequencies around 129 kHz) is used during foraging dives to locate prey (Kyhn et al., 2009). Vocalisations are also used for communication in this species.

The Maui's dolphin is considered by the New Zealand Threat Classification as 'Nationally Critical' and South Island Hector's dolphins as 'Nationally Endangered'. The population size of both subspecies has declined significantly in the last 40 years as a result of bycatch in coastal fisheries (Currey et al., 2012). The populations of relevance to the Operational Area are the East Coast South Island population - 8,968 individuals over a range that extends from Farewell Spit to Nugget Point (Mackenzie & Clement, 2016); and the Maui's dolphin. It has been hypothesised that whilst moving between islands, South Island Hector's dolphins could use shallow waters in the South Taranaki Bight (Hamner et al., 2013).

The distributional range of Maui's dolphins extends along the West Coast of the North Island from Maunganui Bluff to Whanganui (Currey et al., 2012); with a population strong-hold between Manukau Harbour and Port Waikato (Slooten et al., 2005) (**Figure 13**). The most recent population estimate for Maui's dolphins is 63 individuals aged one year and over (95% CI = 57–75) (Baker et al., 2016a). Maui's dolphins are thought to occur in very low densities in Taranaki waters (Currey et al., 2012); however, the capture of a Maui's or hector's dolphin in a commercial set net off Cape Egmont in January 2012 (which was disposed back overboard) confirms their presence in coastal Taranaki waters (DOC, 2017).

No live sightings of Hector's/Maui's dolphins have been reported in the Operational Area. Whanganui, however, is considered to be the southern distributional limit for this species, so theortically some spatial overlap between Maui dolphin habitat and seismic operations could occur. On account of the extremely low population density in the South Taranaki Bight **Figure 13** the likelihood of Maui's dolphins being present is however very low. Four stranding events over the last 30 years have been reported near the Operational Area (two from Whanganui/Manawatu, and two from South Taranaki). In summary, it is possible that both subspecies (Maui's dolphins in particular) could be present in the Operational Area.

Sightings of both subspecies in the South Taranaki Bight are of high scientific value to DOC; therefore special protocols will be implemented during the 18SBB3D seismic survey to facilitate immediate reporting of either subspecies in the event that they are encountered (see **Appendix C**).

5.2.2 Pinnipeds

As listed below, nine species of pinniped are known from New Zealand waters; and based on the criteria in **Table 8**; the following conclusions were drawn about the presence of pinnipeds in the Operational Area:

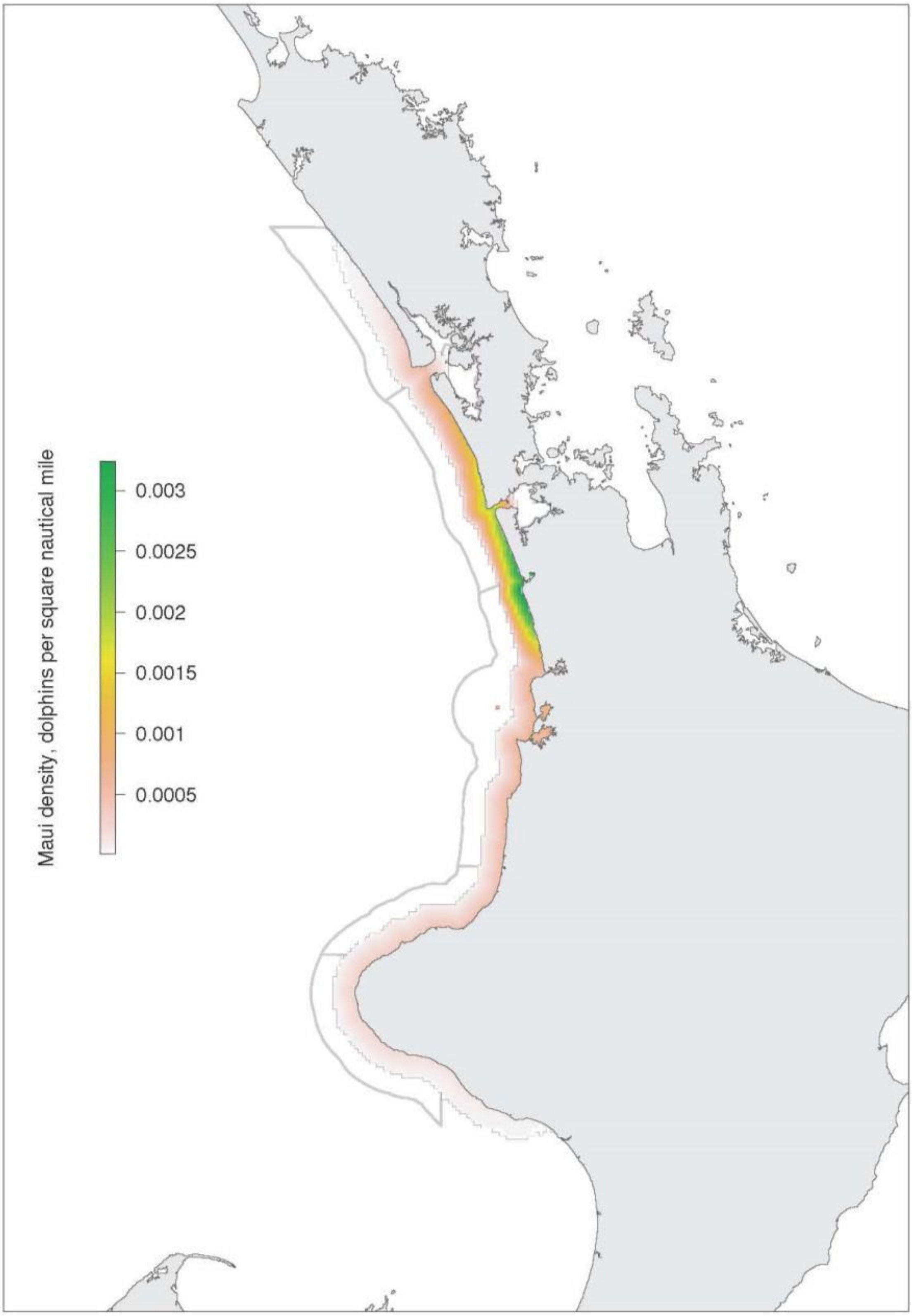
- New Zealand fur seal - Likely;
- Southern elephant seal – Unlikely;
- New Zealand sea lion - Unlikely;
- Subantarctic fur seal - Unlikely;
- Antarctic fur seal - Unlikely;
- Leopard seal – Unlikely (although sightings around the mainland seem to be on the increase);
- Weddell seal - Unlikely;
- Crab eater seal - Unlikely; and
- Ross seal - Unlikely.

The New Zealand fur seal is discussed below as it is the only pinniped species that is likely to occur in the Operational Area.

5.2.2.1 New Zealand fur seal

Subsistence hunting and commercial sealing drastically reduced the population size of New Zealand fur seals from an estimated pre-human population of 3,000,000 to an estimated 100-200 breeding individuals (Emami-Khoyi et al., 2017). This species was afforded protection in 1894, and since then substantial increases in population size and breeding distribution expansion has led to a successful recolonisation of its historic range (Lalas & Bradshaw, 2001). New Zealand fur seals have a wide contemporary distribution around mainland New Zealand; however breeding colonies are mostly located in the South Island (Baird, 2011).

Figure 13 Maui dolphin population density



(Source: Currey et al. 2012: Based on nine aerial and genetic surveys conducted between 2000 and 2012)

New Zealand fur seals feed on fish (e.g. lantern fish, hoki, barracouta and jack mackerel) and cephalopods (arrow squid and octopus) (as summarised by Baird, 2011). Dives reach depths of ~ 200 m and last for up to 12 minutes (Mattlin et al., 1998). Foraging habitats vary with season whereby both inshore and deeper offshore foraging habitat is used throughout the year (Harcourt et al., 2002; Mattlin et al., 1998).

Breeding occurs from mid-November to mid-January, with pupping rate peaking in mid-December (Crawley & Wilson, 1976). Pups are suckled for approximately 300 days and during this time adult females alternate between foraging at sea and returning to shore to feed their pup (Boren, 2005).

The closest breeding colony to the Operational Area is at the Sugar Loaf Islands, off New Plymouth. Numerous breeding colonies occur further south along the northern shores of the South Island. This species is likely to be encountered in the Operational Area.

5.2.3 Seabirds

New Zealand supports the most diverse seabird assemblage on earth; 86 species of seabird utilise the marine waters off New Zealand (DOC, 2017) and 84 species breed in New Zealand waters (Taylor 2000). Close to half (35 species) of the breeding seabirds are classified as endemic, this highest anywhere in the world (Taylor, 2000). Many of the seabirds present in New Zealand have a threatened classification, with several of these amongst the rarest and most critically endangered of New Zealand's breeding birds (Taylor, 2000). 'Seabirds' covers those species that spend some part of their life cycle feeding over the open sea; this is compared to waders that feed in the intertidal or on shorelines (Taylor, 2000). The seabirds present in New Zealand include albatross, skua, cormorants/shags, fulmars, petrels, prions, shearwaters, terns, gulls and penguins.

The Taranaki Bight is visited by a large diversity of seabirds 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 occasionally sighted away from land (Taylor, 2000). Various references, e.g. Scofield and Stephenson (2013), Robertson et al. (2017) and New Zealand Birds Online (2017) have been used to identify the seabirds most likely to be observed in and around the Operational Area. A summary of these species including their New Zealand threat status is presented in **Table 11**. With the exclusion of southern black-backed gulls all New Zealand seabirds are protected by the Wildlife Act 1953.

A number of seabirds have been identified in Taranaki Regional Council's Draft Coastal Plan as being regionally significant on account of their coastal indigenous biodiversity values (Taranaki Regional Council, 2016). These species have been identified in **Table 11** by an asterisk. Taranaki Regional Council also considers Caspian terns, grey-faced petrels, and black-fronted terns as regionally distinctive (Taranaki Regional Council, 2016).

Table 11 Seabird Species That Could be Present in the Operational Area

Common Name	**Scientific Name**	**NZ Threat Status** (Robertson et al. 2017)
Gibson's albatross	*Diomedea antipodensis gibsoni*	Nationally Critical
Antipodean Albatross*	*Diomedea antipodensis antipodensis*	Nationally Critical
Salvin's mollymawk	*Thalassarche salvini*	Nationally Critical
Back-billed gull	*Larus bulleri*	Nationally Critical
New Zealand fairy tern	*Sternula nereis davisae*	Nationally Critical
Black-fronted tern*	*Chlidonias albostriatus*	Nationally Endangered
Grey-headed mollymawk*	*Thalassarche chrysostoma*	Nationally Vulnerable
New Zealand storm petrel*	*Fregetta maoriana*	Nationally Vulnerable
Pied shag*	*Phalacrocorax varius varius*	Nationally Vulnerable

Common Name	**Scientific Name**	**NZ Threat Status** (Robertson et al. 2017)
Black petrel*	*Procellaria parkinsoni*	Nationally Vulnerable
Flesh-footed shearwater*	*Puffinus carneipes*	Nationally Vulnerable
Caspian tern*	*Hydroprogne caspia*	Nationally Vulnerable
Hutton's shearwater	*Puffinus huttoni*	Nationally Vulnerable
Red billed gull*	*Larus novaehollandiae scopulinus*	Declining
NZ white-capped mollymawk/albatross	*Thalassarche cauta steadi*	Declining
Northern little blue penguin*	*Eudyptula minor iredalei*	Declining
White-chinned petrel	*Procellaria aequinoctialis*	Declining
Sooty shearwater*	*Puffinus griseus*	Declining
White-fronted tern*	*Sterna striata striata*	Declining
Sooty tern*	*Onychoprion fuscatus*	Recovering
Northern diving petrel*	*Pelecanoides urinatrix urinatrix*	Relict
Fluttering shearwater*	*Puffinus gavia*	Relict
Broad-billed prion*	*Pachyptla vittata*	Relict
Cook's petrel	*Pterodroma cookie*	Relict
Mottled petrel	*Pterodroma inexpectata*	Relict
Grey-backed storm petrel	*Garrodia nereis*	Relict
White-faced storm petrel	*Pelagodroma marina maoriana*	Relict
Fairy prion*	*Pachyptila turtur*	Relict
Northern royal albatross*	*Diomedea epomophora Sandfordi*	Naturally Uncommon
Southern royal albatross*	*Diomedea epomophora epomophora*	Naturally Uncommon
Buller's mollymawk	*Thalassarche bulleri bulleri*	Naturally Uncommon
Campbell Island mollymawk/albatross	*Thalassarche impavida*	Naturally Uncommon
Chatham Island mollymawk	*Thalassarche eremita*	Naturally Uncommon
Antarctic prion*	*Pachyptilla desolata*	Naturally Uncommon
Northern giant petrel*	*Macronectes halli*	Naturally Uncommon
Grey petrel	*Procellaria cinerea*	Naturally Uncommon
Snare's cape petrel	*Daption capense austral*	Naturally Uncommon
Black shag*	*Phalacrocorax carbo novaehollandiae*	Naturally Uncommon
Little black shag*	*Phalacrocorax sulcirostris*	Naturally Uncommon
Westland petrel	*Procellaria westlandica*	Naturally Uncommon
Buller's shearwater*	*Puffinus bulleri*	Naturally Uncommon
Brown skua	*Catharacta anterctica lonnbergi*	Naturally Uncommon
Arctic skua	*Stercorarius parasiticus*	Migrant
Arctic tern	*Sterna paradisaea*	Migrant
White winged black tern	*Childonias leucopterus*	Migrant
Wandering/snowy albatross	*Diomedea exulans*	Migrant
Short-tailed shearwater	*Puffinus tenuirostris*	Migrant
Southern giant petrel	*Macronectes giganteus*	Migrant
Wilson's storm petrel	*Oceanites oceanicus*	Migrant
Cape pigeon	*Daption capense capense*	Migrant
Eastern little tern	*Sternula albifrons sinensis*	Migrant

Common Name	**Scientific Name**	**NZ Threat Status** (Robertson et al. 2017)
Black browed mollymawk/albatross	*Thalassarche melanophys*	Coloniser
Indian ocean yellow-nosed mollymawk	*Thalassarche carteri*	Coloniser
Southern black-backed gull	*Larus dominicanus dominicanus*	Not Threatened
Australasian gannet	*Morus serrator*	Not Threatened
Little shag	*Phalacrocorax melanoleucos brevirostris*	Not Threatened
Spotted shag	*Stictocarbo puncatus punctaus*	Not Threatened
White-headed petrel	*Pterodroma lessonii*	Not Threatened
Grey faced petrel*	*Pterodroma macroptera gouldi*	Not Threatened

New Zealand has the highest number of endemic breeding seabird species worldwide. The South Taranaki Bight lacks suitable, predator-free breeding habitat for many species (MacDiarmid et al., 2015). Most seabirds have strong natal site fidelity and typically return to the same breeding colony where they were reared, or in the general vicinity (Taylor, 2000). No seabird breeding occurs in the Operational Area; however, there are some species of seabird that seasonally occupy coastal breeding locations in areas adjacent to the Operational Area (**Table 12**). Of particular importance are coastal estuaries in the South Taranaki and Whanganui regions such as the Waikirikiri Lagoon, and Whanganui, Whangaehu, Turakina, Manawatū and Rangitikei River estuaries (Thomson, 2015).

Table 12 Breeding Seabirds in the Vicinity of the Operational Area

Species	**Breeding season**	**Breeding location/s**
White-fronted tern	October – January	Coastal New Zealand
Diving petrel	August – December	Kapiti Island
Sooty shearwater	November – May	Kapiti Island
Southern black-backed gull	September – March	Patea, Manawatū Estuary
Black shag	varies through range	Manawatū Estuary
Little shag	varies through range	Manawatū Estuary
Northern NZ dotterel	August - February	Cape Egmont
Variable oyster catcher	September – March	Manawatū Estuary

Based on GPS tracking data, Poupart et al. (2017) has recently identified the South Taranaki Bight as a foraging ground for little blue penguins (*Eudyptula minor*). Once initially thought to forage within 30 km of their nesting sites, Poupart et al. (2017) have shown that breeding birds from the Marlborough Sounds can forage up to 214 km from their nests. Such long-distance foraging trips are particularly important during the egg incubation stage; eggs are typically laid in July to November with incubation lasting up to 36 days, although second clutches may be laid as late as December (NZ Birds Online, 2017). Following incubation, the chicks are fed by the parents who carry out foraging trips closer to the nest (Poupart, et al., 2017). Little blue penguins nest along the Taranaki coastline. Based on the findings of Poupart et al (2017), there is potential for Taranaki penguins to also carry out large-distance offshore foraging trips into the Operational Area, and for penguins from Marlborough Sounds breeding sites to transit and forage within the Operational Area.

As part of the international Important Bird Area Program, Forest and Bird, Birdlife International and Birds New Zealand, have identified a number of areas within New Zealand as 'Important Bird Areas'. These areas have been identified as internationally important for bird conservation, and are known to support key species and other biodiversity. To date, 141 sites of global significance on land and 69 in the marine environment have been described (Forest & Bird, 2014). There are no Important Bird Areas on Land that are of relevance to the Operational Area (Forest & Bird, 2016).

There is one offshore Important Bird Area of relevance to the Operational Area – Cook Strait. This area is used by seabird colonies for feeding, maintenance behaviours and social interactions, and also encompasses the passage of pelagic species to and from colonies, and congregations close to breeding islands (Forest & Bird, 2014a). The Cook Strait Important Bird Area covers the entire Cook Strait and South Taranaki Bight areas, therefore the Operational Area will overlap with the Important Bird Area. Cook Strait has been identified as an Important Bird Area based on the following listing criteria:

- A1: supports more than threshold numbers of one or more globally threatened species (sooty shearwater, black-backed gull, black-fronted tern, Antipodean albatross, Northern royal albatross, white-capped albatross, Salvin's albatross, Westland petrel, white-chinned petrel, Buller's shearwater and Hutton's shearwater);
- A4ii: contains more than 1% of the global population of one or more congregatory species (fairy prion, fluttering shearwater, Australasian gannet, Westland petrel and Hutton's shearwater); and
- A4iii: contains 10,000 pairs of seabirds, or 20,000 individuals of water-birds (sooty shearwater and 'others').

Although not classified as an Important Bird Area under the Important Bird Area Program, the Manawatū Estuary is listed under the Ramsar Convention on Wetlands as a Wetland of International Importance (DOC, 2017). The Ramsar Convention encourages the "wise use" of wetlands, so that they can be sustained economically, socially, and environmentally (Wetland Trust, 2017). The Manawatū Estuary was listed under the Ramsar Convention in 2005 and is one of six Wetlands of International Importance listed under the Convention in New Zealand. The Manawatū Estuary supports one of the most diverse ranges of birds to be seen at any one place in New Zealand with 121 species having been identified at the estuary (DOC, 2017). At 200 ha in area it is one of the largest estuaries in the lower North Island, and was designated the status of a Wetland of International Importance on the basis of its various geomorphology, presence of rare plants and animals (birds, fish, and invertebrates), and its cultural and social values (DOC, 2017). The estuary is managed by a management group comprised of a number of organisations such as the Manawatū Estuary Trust, local iwi, Horizons Regional Council, Howowhenua District Council, Landcare Trust, and DOC (DOC, 2017). The Manawatū Estuary does not overlap with the Operational Area; however, it has been included here as the estuary would be a vulnerable area in the event of a heavy fuel spill (see **Section 6.3.3**).

5.2.4 Marine Reptiles

Nine species of marine reptile have been recorded in New Zealand waters; the logger head 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, 2017; DOC, 2017). With the exception of the leatherback turtles, marine reptiles are generally found in warm temperate waters. As a result most of New Zealand's marine reptiles are found off the northeast coast of the North Island. All marine reptiles in New Zealand waters are self-introduced and therefore considered native with full protection under the Wildlife Act 1953 (Godoy et al., 2016; DOC, 2017).

The only assessment for sea turtles in New Zealand waters has been done for green turtles. Up until recently, sightings of this species were considered to be of 'strays' and occasional visitors to New Zealand waters that had been incidentally blown ashore by storms and currents. However, Godoy et al. (2016) demonstrated that New Zealand is in fact a temperate intermediary habitat for this species, with individuals actively migrating to New Zealand waters with a year round presence in northern waters. The distribution of other species in New Zealand waters is relatively unknown, but considering the findings of Godoy et al. (2016) it is possible that other turtle species may also actively utilise New Zealand waters.

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 waters of the South Taranaki Bight (DOC, 2017); however, they are rare visitors and are not routinely present. On account of this, the presence of marine reptiles in the Operational Area is considered to be unlikely.

5.2.5 Fish

Fish populations from the Operational Area are represented by various demersal and pelagic species, most of which are widely distributed from north to south and from shallow coastal water to beyond the continental shelf edge. Fishes of the Operational Area occur over a variety of habitats such as over muds, sand, gravel, and reefs, with many of the species present supporting commercial, recreational and customary fisheries (MacDiarmid et al., 2015a). The South Taranaki Bight has a similar level of species richness to the rest of the west coast of the North and South Island, with approximately 12 – 16 species per standard research bottom trawl (MacDiarmid et al., 2015).

Over the summer months when warmer currents move down from the north, a number of larger pelagic species visit Taranaki waters; however, these species tend to be present further west from the Operational Area. The most common of the pelagic species are sunfish, flying fish, marlin, albacore tuna, skipjack tuna, mako sharks and blue sharks.

A general summary of the fish species potentially present in the Operational Area is presented in **Table 13**. The information for this summary table was collated from the NABIS database, the Ministry of Fisheries New Zealand fish guides (McMillan et al., 2011; 2011a), evidence provided for the Trans-Tasman Resources consent process (MacDiarmid et al., 2015a) and more than 35 years of trawl surveys as reported in Anderson et al. (1998), Bagley et al. (2000), Hurst et al. (2000), and O'Driscoll et al. (2003). Over 1,000 species of fish occur in New Zealand waters (Te Ara, 2017a); therefore it is worth noting that the table below is not intended to provide an exhaustive list of all species present within the Operational Area, but is an indication only of the main species. Species that have been reported to be particularly abundant (MacDiarmid et al., 2015a) are shown in **Table 13** as bolded text.

Rocky reefs in the South Taranaki Bight are typically found within the CMA, for example the North and South Traps, support a range of small reef fish such as various species of triplefins and eels, as well as larger fish such as blue cod, moki, leatherjackets and butterfish.

Table 13 Fish species potentially present within the Operational Area

Common Name		
Trawl surveys (Anderson et al., 1998; Bagley et al., 2000, Hurst et al., 2000, 2000a; O'Driscoll et al., 2003) [1] NABIS Database [2] McMillan et al. (2011, 2011a) [3] Trans-Tasman Resources references (MacDiarmid et al., 2015a)[4]		
Anchovy[2,4]	Giant stargazer[1,2,3]	Red pigfish[4]
Arrow squid (Gould's & Sloan's)[1]	Greenback jack mackerel[3]	**Rig[1,2,3,4]**
Barracouta[1,2,3,4]	Goatfish[4]	Rock cod[4]
Basking shark[2]	Golden mackerel[2,4]	Rough skate[1,2,3]
Bass[2]	Gurnard [1]	Sand flounder[1,2,3,4]
Black flounder[2]	Hake[2]	Scaly gurnard[1,4]
Black oreo[1]	Hapuku[1,2,3,4]	**School shark[1,2,3,4]**
Blue cod[1,2,3,4]	Hoki[1,3,4]	Sea perch [1,2,3,4]
Blue mackerel[1,2,3,4]	Horse mackerel[2,4]	Short-tailed black ray[3,4]
Blue marlin[2]	Jack mackerel[1]	Shorttail stingray[1]
Blue moki[2,4]	John dory[1,2,3,4]	Silverside[3,4]
Bluenose[2,4]	Kahawai[1,2,3,4]	Silver warehou[1,2,3,4]
Blue shark[2]	Kingfish[1,2,3,4]	Skipjack tuna[3]
Blue warehou[1,2]	**Leatherjacket[1,2,3,4]**	Slender jack mackerel[3]
Brill[2]	Lemon sole[1,2,3,4]	Slender roughy[4]
Broadbill swordfish[2]	Ling[2,3,4]	Smooth skate[1,2,3]
Broad squid[1]	Mako shark[2]	**Snapper[1,2,4]**
Bronze whaler shark[2,3]	Marblefish[4]	**Spiny dogfish[1,2,3,4]**
Brown stargazer[2]	Moonfish[2]	Southern bastard cod[4]
Butterfish[4]	Murphy's mackerel[1,2,4]	Spotted stargazer[1,2,3,4]
Butterfly perch [1,3]	New Zealand sole[2,4]	Spotty[4]
Carpet shark[1,3,4]	Northern spiny dogfish[1,2,3,4]	Striped marlin[2]
Common roughy[4]	Pilchard[1,2,3]	**Tarakihi[1,2,3,4]**
Common warehou[3,4]	Porae[2,4]	Thresher shark[1,2,3]
Conger eels (multiple sp.)[1]	Porcupine fish [1,3,4]	**Trevally[1,2,3,4]**
Cucumber fish[1,3,4]	Ray's bream[2,4]	Turbot[2]
Dwarf scorpinfish[4]	Redbait[1,2,3]	Two saddle rattail[3]
Eagle ray[1,3,4]	Red-banded perch[4]	White pointer/great white shark[2]
Electric ray[1,3]	Red cod[1,2,3,4]	White trevally[1]
Escolar[2]	**Red gurnard[1,2,3,4]**	Witch[4]
Frostfish[1,2,3,4]	Red moki[2,4]	Yellowtail jack mackerel[3]
Gemfish[3,4]	Red mullet[4]	Yellow-bellied flounder[4]

Eight species of fish are listed as protected under Schedule 7A of the Wildlife Act. These are: basking shark, deepwater nurse shark, great white shark, manta ray, oceanic white-tip shark, spiny-tailed devil ray, spotted black grouper, and whale shark. In addition to the protection offered under the Wildlife Act, the great whites, basking sharks and oceanic white-tip sharks are also protected under the Fisheries Act 1996, prohibiting New Zealand flagged vessels from taking these species from all waters, including beyond New Zealand's EEZ. Of these protected species, the great white shark and basking shark have the greatest potential to occur in the Operational Area.

Areas utilised by fish for spawning and pupping (birth of live young) may be disproportionately important to fish populations; any disruption to spawning or pupping activity may result in a reduction in recruitment (Morrison et al., 2014). Spawning activity ranges from large spawning aggregations, to localised groups of spawning fish, or single pairs of individuals. Large aggregations may involve large scale migrations (transient aggregations) or short distance migrations of local fish (resident aggregations) (Morrison et al., 2014). Knowledge on the spawning and pupping of New Zealand's fish is typically limited, with detailed information about spawning activity only well known for a few species, for example commercially important species such as orange roughy and hoki. Data on the presence of spawning/pupping locations usually relies on the reported catch of spent or ripe running females from research trawls. Species potentially spawning/pupping along the shelf in the south-west of the North Island have been provided in **Table 14** based on Morrison et al. (2014), Hurst et al. (2000a) and O'Driscoll et al. (2003). An indication of the probability of each species spawning has been provided based on evidence in Hurst et al. (2000a) as presented in MacDiarmid et al. (2015a): probable = good evidence based on gonad state, possible = presence of small juveniles, and unlikely but possible = presence of larger juveniles. Findings from Hurst et al. (2000a) and O'Driscoll et al. (2003) need to be interpreted with caution as they indicate only where catches of certain life stages took place on trawlable ground deeper than 20 m; shallow area and areas with bottom features too rough to trawl were not sampled (MacDiarmid et al., 2015a).

Large harbours along the west coast of the North Island (in particular Kawhia Harbour), Tasman Bay, and the Marlborough Sounds are important nursery grounds for a number of fish species (e.g. snapper, school shark, and elephant fish) (Hurst et al., 2000). Adults migrate in to these sheltered bays to spawn/pup; therefore they may be present within the Operational Area during such movements.

Table 14 Fish Species Potentially Spawning in the Operational Area

Species common name	Probability of spawning	Species common name	Probability of spawning
Arrow squid	Unlikely but possible	New Zealand sole	Probable
Barracouta	Unlikely but possible	Red gurnard	Unlikely but possible
Blue mackerel	Probable	Rig	Probable
Blue cod	Possible	Sand flounder	Probable
Blue warehou	Unlikely but possible	School shark	Unlikely but possible
Giant stargazer	Unlikely but possible	Sea perch	Possible
Golden mackerel	Probable	Snapper	Unlikely but possible
Jack mackerel	Unlikely but possible	Spiny dogfish	Unlikely but possible
John dory	Possible	Tarakihi	Unlikely but possible
Kahawai	Possible	Trevally	Unlikely but possible
Kingfish	Possible	Yellow-belly flounder	Probable
Lemon sole	Probable	Yellow-eyed mullet	Probable

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*). As well as being found in New Zealand, the short-finned eel also occurs throughout Australia. A third species, the spotted eel (*A. reinhardtii*), has recently been found in northern rivers of New Zealand, where it is thought to be a new arrival from Australia (Te Ara, 2017b).

Under the New Zealand Threat Classification System (Goodman et al., 2013) long-finned eels are classified as 'Declining' and short-finned eels as 'Not Threatened'. Both species 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; they 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. These young eels move at night or during floods during which time they find suitable cover and feeding grounds in the lower reaches of streams. Here 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. This migration further upstream occurs annually in January (Cairns, 1950).
- 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, and follows a distinct pattern. 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. Long-finned eels show a similar pattern whereby the males migrate before the females, with this migration occurring after that of the short-finned eels (Cairns, 1950). Adult eels move to the sub-tropical Pacific Ocean and although the exact location and migration route for spawning is not known (as eel spawning has never been observed), deep ocean trenches (DOC, 2017) near Fiji and New Caledonia are thought to be important spawning grounds (NIWA, 2017). Short-finned and long-finned eels are semelparous; that is they breed only once at the end of their life (DOC, 2017), therefore there is no southern migration of adults returning to New Zealand.
- A fourth, unobserved migration occurs involving the leptocephalus young (transparent leaf-shaped eel larvae). 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, 2017b) before commencing their freshwater life-cycle as elvers (see first point).

5.2.6 Cephalopods

There are over 100 species of cephalopod in New Zealand of which 23 have yet to be described (Tracey et al., 2011; Te Ara, 2017). Cephalopoda contains four groups which are represented in New Zealand waters: squid (order Teuthida), octopus (order Octopoda), vampire squid (order Vampyromorphida) and cuttlefish (order Sepiida). Octopus and squid are an invaluable food source for a number of bird, mammal, and fish predators, and are typically short lived (1 – 2 years), fast growing and only spawn once before dying (MFish, 2008).

In total 42 octopus species are recognised from New Zealand waters; of these, 68% are endemic (O'Shea, 2013). The common octopus, (*Octopus maorum*) is frequently encountered in the inshore subtidal coastal zones and is distributed throughout New Zealand. Benthic monitoring around Taranaki oil fields have reported juveniles of this species in samples (pers. obs. N. Pannell); hence it is likely that this species would be present in the Operational Area. The small *Octopus huttoni* is also found throughout New Zealand in the intertidal and subtidal to depths of 250 m (Marinelife, 2017), so presumably this species would be present in the Operational Area as well.

New Zealand has a diverse assemblage of squid, vampire squid and cuttlefish; with more than 85 species recorded from New Zealand (Te Ara, 2017d). The majority of these species are pelagic and inhabit open water habitat. The cuttlefish, *Sepioloidea pacificais*, has more of an inshore distribution; occurring in soft sediments around coastal New Zealand (Marinelife, 2017).

The New Zealand squid fishery focusses on two species of arrow squid; Gould's arrow squid (*Nototodarus gouldi*) and Sloan's arrow squid (*Nototodarus sloanii*). These species are found across the continental shelf in water depths up to 500 m, but are most commonly caught in waters less than 300 m (MPI, 2017). Squid have a rapid growth rate and are thought to only live for a year (MPI, 2017). Arrow squid have been caught within the Taranaki Bight during research trawl surveys (Bagley et al., 2000); however, arrow squid are not commercially targeted here as greater biomass for these species occurs in the subantarctic fishing grounds (Deepwater Group, 2017). MacDiarmid et al. (2015) assessed trawl data for the Patea Shoals region and noted that at the shallow sample stations (<50 m), squid and octopus were the only taxonomic groups represented in trawl samples; hence these taxonomic groups will certainly be present in the Operational Area.

5.2.7 Benthic Invertebrates

Subtidal benthic habitats in the South Taranaki Bight include soft sediment habitats, hard rock habitats and mudstone habitats (Anderson et al., 2013). The soft sediments and mudstone habitats are characterised by low species abundance and diversity, while the hard rock habitats support abundant and diverse macrobenthic assemblages. A number of these hard rock habitats are recognised as ecologically significant (e.g. the North and South Traps) (see **Section 5.3.1.1**).

The Operational Area extends into a region known as Patea Shoals. Habitat analysis here was undertaken by Beaumont et al. (2015) who collected visual observations at 144 sites, infauna samples at 103 sites and macrofauna samples at 116 sites. The key findings of this analysis revealed that the most common habitat type was rippled sand which occurred mostly in the inner shelf and mid-shelf zones. Rippled sand habitat had low biodiversity and low densities of infauna and epifauna in keeping with the highly exposed, shallow, sandy nature of this region. In the mid-shelf zone, the most common infauna species was the sabellid tubeworm *Euchone sp*. which was present in patchily distributed 'wormfields'; occurring in areas of flat sea bed with medium to fine sediments. Two types of biogenic habitat were common in deeper offshore areas: bivalve rubble (primarily the dog cockle *Tucettona laticostata*) and bryozoan rubble. These habitats both supported diverse communities of bryozoa, sponges, ascidians, brachiopods, bivalves, crabs, brittle stars, sea cucumbers, gastropods and sea slugs. No species recorded during the assessment are listed as threatened by the New Zealand Threat Classification System (Freeman et al., 2010); however, six taxa of molluscs identified are considered naturally uncommon.

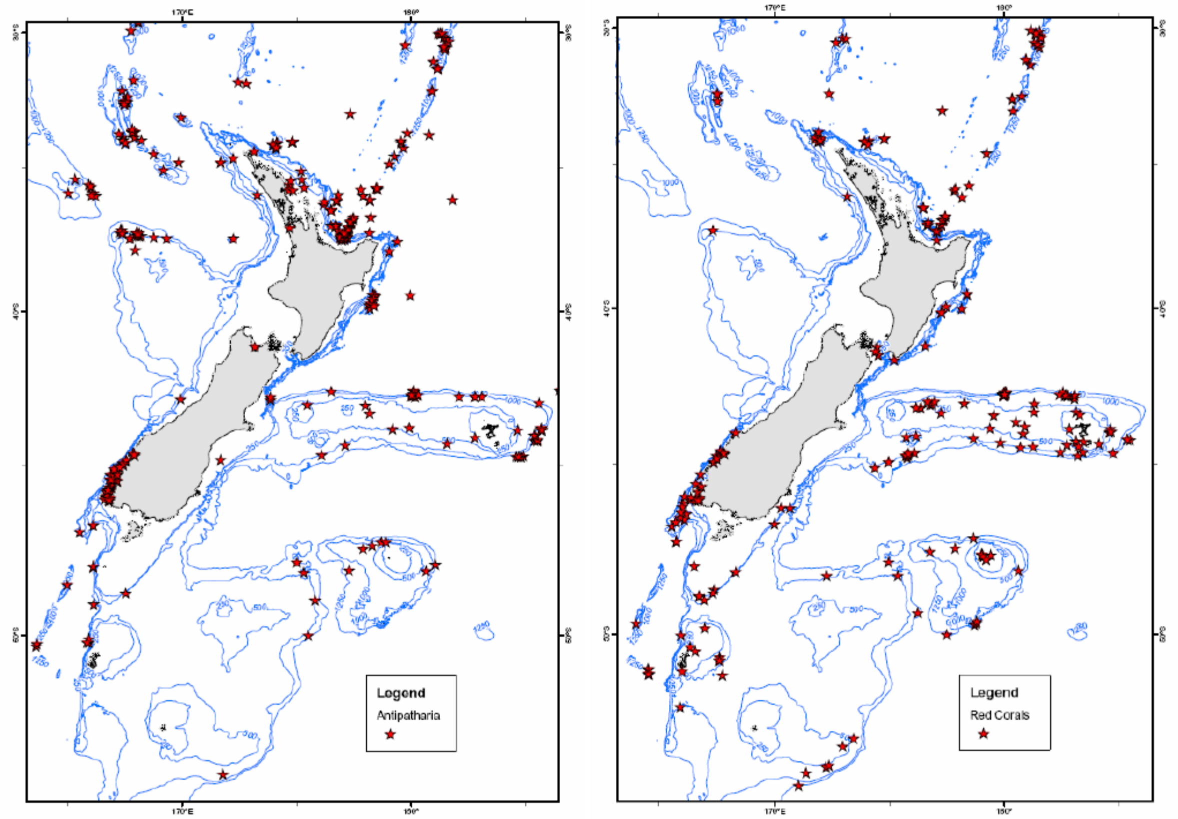
The soft benthic ecosystems further offshore of Patea Shoals have relatively low species diversity and are homogenous (Asher, 2014; Skilton, 2014). They are generally characterised by soft sand/mud substrates that supports mainly polychaete worms, cumaceans, amphipods (small crustaceans), and bivalves (Handley, 2006). Over 200 invertebrate taxa have been recorded in the offshore area, where polychaetes (bristle worms) account for 45-65%, molluscs (mainly bivalves) account for 10-20% and crustaceans (such as shrimps, amphipods and cumaceans) account for 15-35% of the benthic communities (pers. obs. C. Dufour).

New Zealand has a rich and diverse range of corals that are present from the intertidal zone down to 5,000 m (Consalvey et al., 2006). The protected deep sea corals (such as black coral and stylasterid hydrocoral), are the most relevant to any environmental impact assessment on account of the protection they are afforded under the Wildlife Act 1953. Based on records from commercial fishing bycatch, NIWA have developed a database of coral distribution around New Zealand. The database identifies no significant densities of black coral or stylasterid coral in the Operational Area (**Figure 14**). Hence corals are not considered further in this MMIA.

No other benthic species considered to be 'at risk' or 'threatened' (under the New Zealand Threat Classification System) have been found in coastal or offshore Taranaki waters (MacDiarmid et al., 2015). However, **Section 5.3.4** outlines sensitive benthic habitats that may be present (including bivalve beds, sea pens, chaetopteridae worm-fields, brachiopods and bryozoans).

In 2016, the Taranaki Regional Council identified the following as indigenous species that are regionally significant for their coastal indigenous biodiversity values: the hydrozoan *Nemertesia elongata*; the whelk *Cominella quoyana griseicalx*; the spider crab *Leptomithrax tuberculatus mortenseni*; the cushion star *Eurygonias hyalacanthus* and the stony coral *Maldrepora oculata* (Taranaki Regional Council, 2016). It must be noted that this report (Taranaki Regional Council, 2016) remains a draft, and none of these invertebrates have been recorded in the offshore habitats associated with the Operational Area (pers. obs. C. Dufour).

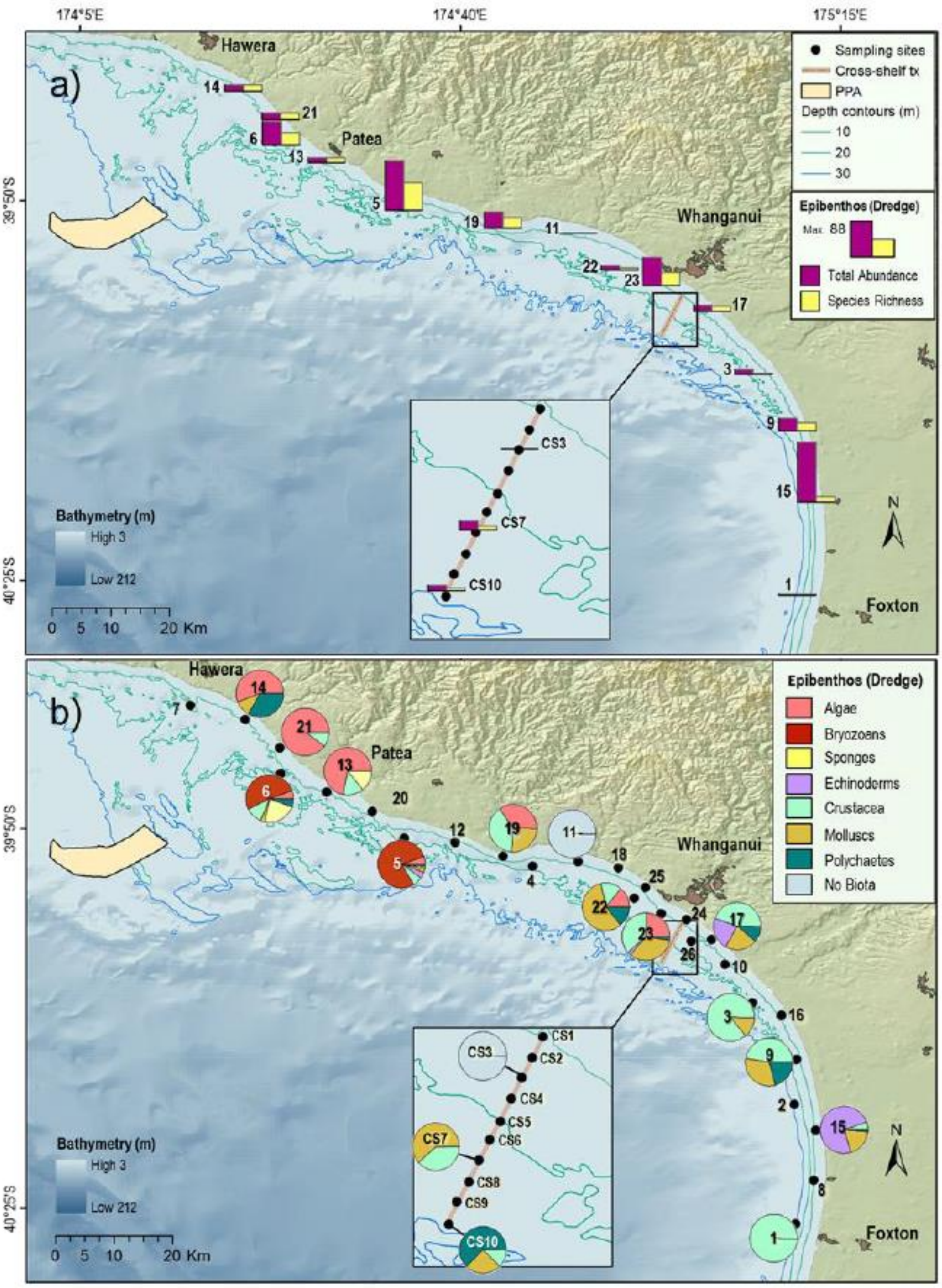
Figure 14 Distribution of Black Coral (Left) and Stylasterid Coral (Right)



Source: Consalvey et al (2006)

The coastal area adjacent to the Operational Area hosts a range of environments which vary in substrate (reefs, boulders, sand, etc.), coastal morphology (harbours and estuaries), water temperature and exposure to wave action. These factors directly impact the occurrence of various species within the intertidal zone. Species number and diversity tends to increase towards the shore, with highest numbers in the nearshore area (MacDiarmid et al., 2015; MacDiarmid et al., 2015a). Overall, molluscs tend to dominate rocky shores, while mobile invertebrates are often the most commonly observed in soft shores. On hard shores, sessile invertebrate species (i.e. sponges, ascidians, bryozoans, and hydroids) are conspicuous and form stable communities (Lavery et al., 2007) (**Figure 15**).

Figure 15 Macrobenthic assemblages collected in the vicinity of the Operational Area



Key: a) Histograms of total abundance and species richness at each dredge site, and b) The proportion of major taxonomic groups collected at each dredge site; where PPA relates to the 'proposed project area' for a recent iron sand mining application. Source: Anderson et al., 2013

5.2.8 Plankton

'Plankton' is the collective term for drifting organisms that inhabit the pelagic zone (water column) of the world's oceans. Plankton fulfils the primary producer role in the ocean and forms the basis of the marine food web. Plankton travel with the ocean currents and although some plankton can move vertically within the water column, their horizontal distribution is primarily determined by the surrounding currents. There are four broad functional planktonic groups:

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

The Greater Cook Strait region (including the STB) is impacted by several large scale physical phenomena (e.g. the Kahurangi upwelling, tidal mixing, and river plumes) that structure the distribution and biomass of zooplankton, which is mediated by the pattern of distribution of phytoplankton biomass and its resulting primary productivity (Bradford-Grieve & Stevens, 2015). This semi-enclosed area is considered to be one of the most biologically productive coastal regions in New Zealand (MacKenzie, 2014).

Due to the absence of mixing of water in summer resulting in stratification of the water column, phytoplankton is able to remain at the sea surface and continuously photosynthesise throughout daylight hours. However, in the process of photosynthesising, the phytoplankton use up available nutrients in the surrounding water, resulting in a decline in primary productivity. Phytoplankton biomass also declines with the increase in grazing zooplankton (Bradford-Grieve & Stevens, 2015).

Off Cape Farewell to the north-west of the South Island, cool, high salinity water that are rich in dissolved inorganic nutrients bring isolated patches of nutrient pulses into the South Taranaki Bight. These pulses travel in the north-easterly direction, increasing the availability of nutrients for phytoplankton, causing an increase in chlorophyll-α concentration. The result is a change in species composition of the zooplankton communities, with this upwelling system particularly important for *Nyctiphanes australis*, a resident species of krill that is an important food for fish, seabirds, squid and baleen whales. Recent studies by Torres et al. (2017) have identified the South Taranaki Bight as a hot-spot for pygmy blue whales; with high abundances of *N. australis* a driving factor (see **Section 5.2.1.1**).

An area of elevated chlorophyll-α also exists off the Manawatu River in conjunction with elevated levels of dissolved reactive silica. Highly productive surf diatoms have also been recorded at Waitarere Beach, south of the Manawatu River possibly due to river run-off (Bradford-Grieve & Stevens, 2015).

Zooplankton sampling carried out in the 1970s and 1980s throughout the South Taranaki Bight (including more offshore waters around the Maui oil field) showed elevated zooplankton biomass in summer when compared with other near-shore regions, with the salp *Thalia democratica* dominating the catches. Zooplankton species composition within the South Taranaki Bight was concluded to be typical of nearshore zooplankton communities around the North Island (Bradford-Grieve et al., 1993). As the majority of this sampling was carried out in summer and autumn, no seasonal patterns can be concluded (MacDiarmid et al., 2015).

Sampling of zooplankton in 2015 near the Operational Area found the highest biomass of zooplankton over the Patea Shoals with no obvious inshore-offshore spatial pattern in biomass. Biomass was dominated by *T. democratica* at three of the stations, juvenile euphausiids dominated the zooplankton biomass at two of the stations, while biomass at the remaining stations was dominated by copepods. Across all stations, copepod fauna was dominated by two omnivorous genera (*Oithona similis* offshore and *Paracalanus indicus* inshore). Herbivorous and carnivorous copepods were also present, although in much lower abundances (MacDiarmid et al., 2015).

5.3 Coastal Environment and Marine Conservation

5.3.1 Regional Coastal Environment

The Operational Area is situated in the South Taranaki Bight, south-east of the tip of Cape Egmont. The Operational Area lies across both the EEZ and the CMA. The coastline adjacent to the operational area is discussed below as this area could potentially be affected in the unlikely event of an oil spill. The CMA associated with the Operational Area is under the jurisdiction of Taranaki Regional Council and Horizons Regional Council (**Figure 16**).

The coastline of the Taranaki region is long and encompasses a broad range of habitats including rocky shores and cliffs, sandy beaches, subtidal reefs, river mouths, and estuaries. The intertidal reef systems along this coastline generally have a lower species diversity and abundance than similar system types elsewhere in New Zealand. The high energy coastline gives rise to abrasive and turbulent shoreline conditions, high water turbidity, suspended silt, and sand inundation. The rocky inshore marine environment of Taranaki provides a range of different habitats for species such as starfish, sea anemones, crabs, crayfish, sea cucumbers, mussels, paua, sponges, whelks, fish and seaweed. Approximately 16% of the coastline in Taranaki is made up of estuaries and river mouths. These estuaries do not have a wide range of intertidal and subtidal habitats and are well flushed with fresh water, resulting in a harsh environment for estuarine species and low species diversity (TRC, 2009).

The west coast of Manawatu-Wanganui (collectively referred to as the Horizons region) is characterised by narrow sandy beaches that are backed by sea cliffs in the north, and sandy beaches backed by dynamic dune systems from Whanganui south. Several large estuaries are located along this stretch of coast, the majority of which have extensive tidal flats and are specifically noted for being important habitat for birds. The coast is a high energy environment, with wave heights commonly in excess of 3 m (Horizons, 2014).

The following is a brief overview of the coastal/shoreline environment of the South Taranaki Bight, based on the coastal sections as reported in MacDiarmid et al. (2015).

Cape Egmont to Mangahume Stream

This very exposed section of coastline consists of hard lahar and soft ash bed rock. The shoreline is dominated by large sections of beach and cliff, a number of small streams, and a pocket beach located at Opunake. Opunake's Middleton Beach is a rock platform that is covered by a thin veneer of sand. Major features of this section include Oaonui and Opunake.

Mangahume Stream to Inaha Stream

This section of coastline is the last section of the volcanic lahar coast. The shoreline is mostly hard cliffs dissected by ring plain rivers and streams. There are sand dunes near Kaupokonui Stream; an unusual feature for this coastal section. Major features of this section include Pihama, Otakeho, Kaupokonui, Manaia, and Inaha.

Inaha Stream to Patea

From Inaha Stream to Patea is a transition from hard volcanic lahar cliffs to soft sedimentary cliffs. The shoreline has continuous eroding sedimentary cliffs with steep sand or gravel beaches at their base. A number of papa reefs lie offshore. Three rivers (Waingongoro, Tangahoe, and Manawapou) have carved tracks through the cliffs to the ocean. Major features of this section include Ohawe, Hawera, Karamea, and the Waingongoro, Tangahoe and Manawapou Rivers.

Patea to Waitotara

The rock base of this section of coastline is soft sedimentary rock. The shoreline is dominated by sand beaches that are backed by dunes and sand country, with the exception of high cliffs from Waipipi to Caves Beach. Due to the local wave climate, inputs of sediment from rivers and cyclic sand levels within the Patea estuary, the shoreline around Patea River and Patea Township is dynamic, with periods of both erosion and accretion. Major features of this coastal section include the Whenuakura, Waverly, Waipipi, and Waitotara Rivers.

Waitotara to Whangaehu River

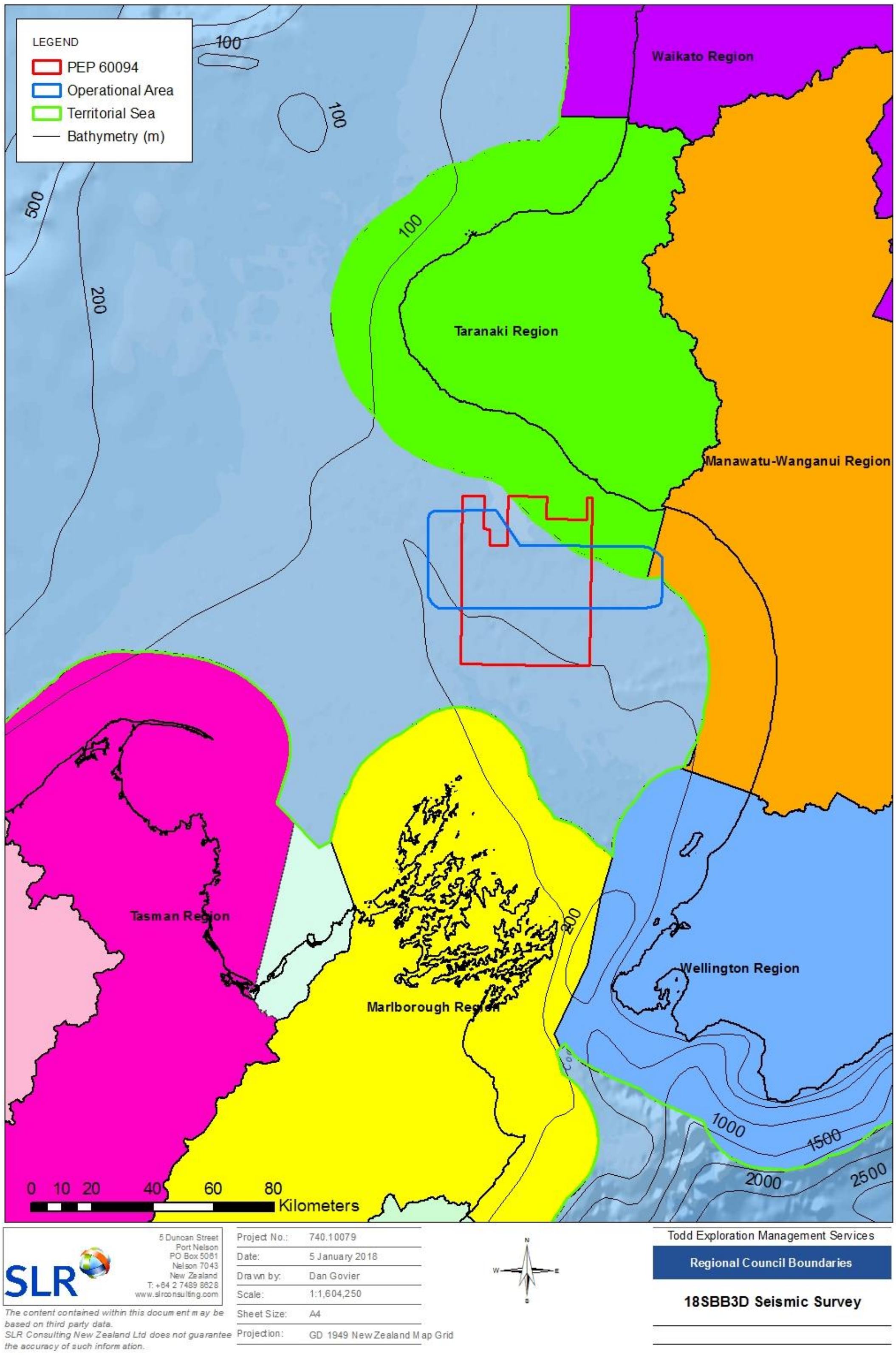
This section of coastline includes Whanganui, around which is a tectonically active sedimentary coast. The shoreline of this section consists of narrow sandy beaches that are backed by erosive sedimentary cliffs. Major features of this coastal section include Waiinu, Mowhanau Beach, Kai iwi beach, and Whanganui.

Whangaehu River to Waikawa Beach

The geology of this coastline is sedimentary in nature, with the shoreline consisting of sandy beaches backed by dunes and prograding sand country which can extend up to 20 km inland due to the prevailing westerly wind blowing the sand inland. The shoreline at the rivers mouths is dynamic, with river mouth movement of several hundred meters having been recorded. Major features of this section include the Turakina, Rangitikei, and Manawatu Rivers, Koitiata, Moana Roa Beach, Tangimoana, Himatangi Beach, Foxton Beach, Waitarere, Hokio, and Waikawa Beach.

Within their jurisdiction each council has identified a range of different habitats and areas of significance that are unique to that region. These areas are identified and described in more detail below. It is important to note that no spatial overlap will occur between these areas and the Operational Area; however, they are included here to provide a coastal context in the unlikely event of a heavy fuel oil spill (see **Section 6.3.3**).

Figure 16 Regional Council Boundaries in Relation to the Operational Area



5.3.1.1 Taranaki Areas of Outstanding Coastal Value

The Taranaki Regional Coastal Plan is currently undergoing a review and is due for implementation in early 2018. As a result, the following information on the Taranaki coastal environment has been extracted from the Draft Coastal Plan. Within the Draft Coastal Plan, Taranaki Regional Council has sectioned the coast into five Coastal Management Areas. These are areas that are recognised for their values, characteristics or uses that are vulnerable or sensitive, or that require specific management styles (Taranaki Regional Council, 2016). The activities that are permitted to occur within each management area are outlined in the Draft Coastal Plan. Taranaki Coastal Management Areas are as follows:

- Outstanding Value Areas: these are areas that have outstanding natural character and areas that have been identified as outstanding natural features and landscapes. They contain a number of 'exceptional' values and attributes, such as landforms, cultural and historic associations, and visual qualities;
- Estuaries Unmodified: are estuaries that retain their naturalness and have not seen significant human modification, and includes the surrounding area and environment;
- Estuaries Modified: include estuaries that have been highly modified and are surrounded by urban development and extensively modified environments. Examples include Patea, Waiwhakaiho, and Waitara. Despite being highly modified, these areas retain indigenous biodiversity values, amenity values, and contain significant habitats;
- Ports: this area covers Port Taranaki which contains regionally and nationally important infrastructure; and
- Open Coast: is the area within the CMA that is not covered by the other four Management Areas.

Outstanding Value Areas are defined as either Areas of Outstanding Natural Value, or as Areas that are Outstanding Natural Features or Landscapes. A summary of these areas in the South Taranaki Bight and their relevant coastal features are provided in **Table 15** and **Table 16** below.

In addition to the Areas of Outstanding Natural Character and Areas that are Outstanding Natural Features or Landscapes are a number of Sites with Significant Amenity Values. These are based on the natural or physical qualities and characteristics of an area that contribute to its pleasantness, aesthetic coherence, and cultural and recreational attributes. Taranaki Sites with Significant Amenity Values include 22 beaches, 48 reefs, and 10 estuaries and river mouths. 103 Significant Surf Breaks and Nationally Significant Surfing Areas, and 29 Sites of Geological Significance have also been identified throughout Taranaki by the Draft Coastal Plan (Taranaki Regional Council, 2016).

Table 15 South Taranaki Areas of Outstanding Natural Character

Area	Value
Whenuakura Estuary*	Contains diverse and relatively unmodified habitats - extensive mudflats, tidal lagoons, a freshwater lagoon, unmodified mudstone coastal cliffs, and a sand bar with an island forming intermittently. Several threatened/ at risk plants and animals are present. It is the migratory route of several bird species. There is minimal modification maintaining strong wild and scenic associations.
Waipipi Dunes*	Consists of a highly dynamic complex of low (<4 m) dunes and small wet sand flats and depressions extending from the coast inland 200 – 300 m to taller (15 m) more stable relic foredunes. It is the only sizeable area in the Foxton Ecological Area with no artificially induced erosion and includes a Significant Natural Area and Regionally Significant Wetland. The unmodified dune landforms retain a strong sense of wildness and isolation.
North and South Traps*	Two large adjoining pinnacle reefs (unusual features on the sand dominated shelf). Contains important kelp beds, a range of fish, encrusting sponges, and crayfish habitat. The experience maintains a high sense of wilderness and remoteness.
Waitotara*	An actively eroding broken foredune and series of extensive undulating dunes with hollows and relic foredunes further inland parallel to the beach. Contains a system of wetlands providing habitat for threatened and at risk plants and animals. Human activity is minimal and the experience maintains a high sense of wilderness and remoteness.
Areas marked with an asterisk are also considered to be Taranaki Coastal Areas of Local or Regional Significance	

Table 16 South Taranaki Outstanding Natural Features or Landscapes

Area	Value
Oaonui (Sandy Bay)*	Largely unmodified and forms the only significant remaining area of coastal sand dunes within the volcanic ring plain. A geopreservation site. Provides important bird feeding, breeding, and resting areas. Provides habitat for a range of threatened and rare plants and animals. Very high recreational, historic and cultural values.
Kaupokonui	Contains significant scientific values and has threatened, at risk, and regionally distinctive plants. Whitebait spawning site. Retains a high level of naturalness. Considered the 'Jewel of South Taranaki' and is valued by locals and tourists. Significant to Ngā Ruahine Iwi and contains important cultural and archaeological sites.
Kapuni Stream Mouth	Supports threatened, at risk, and regionally distinctive plants and animals. Retains a strong level of naturalness. Contains important historic (site of first clash between Māori and British troops) and cultural sites; pā, kāinga, tauranga waka, and pūkāwa.
North and South Traps*	Popular recreational fishing and diving area approximately 13 km north of the Operational Area; known by local iwi and hapu as a rich fishing ground.
Waverly Beach*	Contains a range of coastal stacks, caverns, ravines, and blow holes carved into the cliffs and is recognised as a geopreservation site. Threatened/at risk plants and animals are present. High scenic and recreational values, as well as significance for tangata whenua as mahinga kai. Contains significant pā and kainga including Tauranga waka.
Waitotara	Contains several geopreservation sites, seabird feeding, breeding and resting areas, and several threatened/at risk species. Is a popular fishing area and contains significant pā and kainga, including tauranga waka and mahinga kai.
Areas marked with an asterisk are also considered to be Taranaki Coastal Areas of Local or Regional Significance	

Taranaki Regional Council, New Plymouth District Council, South Taranaki District Council, and DOC have collaborated to develop a list of coastal areas of local or regional significant in the Taranaki Region. These areas were developed independently to the Areas of Outstanding Natural Value and Areas that are Outstanding Natural Features or Landscapes. They are considered significant due to their amenity, recreational, cultural/historic, and/or ecological/scientific values (Taranaki Regional Council, 2004). **Table 17** provides a summary of the areas of local or regional significance within the South Taranaki Bight that have a marine component. Areas already mentioned in **Table 15** and **Table 16** have been indicated within these tables by an asterisk and are not repeated in **Table 17**.

Table 17 South Taranaki Coastal Areas of Local or Regional Significance

Site	Values			
	Amenity	Recreational	Cultural/ historic	Ecological/ scientific
Cape Egmont	Moderate	Moderate	High	High
Arawhata Road Beach	High	Moderate	Not known	High
Middletons Bay	High	Moderate	High	Moderate
Opunake Beach	High	High	High	High
Mangahume Beach	High	Moderate	Moderate	Not known
Puketapu Road End	Moderate	Moderate	High	High
Oeo Cliffs	Moderate	Moderate	High	Moderate
Rawa Stream Mouth	Moderate	Moderate	High	Moderate
Otakeho Beach	High	Moderate	Not known	High
Kaupokonui Stream	High	High	High	High
Inaha Beach	High	Moderate	Not known	Not known
Waingogoro River, Ohawe Beach and Four Mile Reef	High	High	High	High
Waihi Beach	Moderate	High	High	Moderate
Kakaramea Beach	Moderate	Moderate	High	Moderate
Patea Beach and River Mouth	Moderate	High	High	High
Waiinu Beach and Reef	High	High	High	High

5.3.1.2 Manawatu – Wanganui Protection Areas

Horizons Regional Council manages part of the CMA on both the west and east coasts of the North Island. The western coastline covers approximately 120 km from Waiinu Beach in the north to Waikawa Beach in the South, and includes the Wanganui, Rangitikei, Manawatu and Horowhenua districts. The One Plan (Horizons, 2014) describes a number of Protection Activity Management Areas. These areas have been identified based on their ecological or 'other' (e.g. historic and cultural) important characteristics, and are described in **Table 18**.

Table 18 Horizons Protection Activity Management Areas

Protection Activity Management Area	Ecological and Other Important Characteristics
Whanganui River	Nationally important as a nursery for freshwater and estuarine species. Nationally important ecosystem for birds and a strategic site for migratory bird species. Provides habitat for threatened species including important roosting and feeding areas for wading birds. Important feeding and breeding ground for many fish. The coastal landforms and adjacent dunes are important nesting habitat. Contains historic heritage.
Whangaehu River	Nationally important strategic site for migratory bird species. Provides habitat for threatened bird species. Important roosting and feeding habitat for wading birds. Regionally distinct vegetation communities. Regionally important for its high degree of naturalness. Locally rich in archaeological sites.
Turakina River	Nationally important strategic site for migratory bird species. Provides habitat for threatened bird species. Important roosting and feeding habitat for wading birds. Regionally distinct vegetation communities. Regionally important for its high degree of naturalness. Locally rich in archaeological sites.
Rangitikei River	Contains regionally important plant species. Regionally important for bird species, saltmarsh communities, and estuarine native turf. Provides habitat for rare and threatened birds. Important roosting and feeding area for wading birds and whitebait spawning. Historic heritage.
Manawatu River	Nationally important as a nursery for freshwater and estuarine species. Internationally important strategic site for migratory birds. Provides habitat for rare and threatened birds. Important roosting and feeding area for wading birds. Contains regionally important plants. Internationally recognised as a wetland of international importance under the RAMSAR Convention. Regionally important for its high degree of naturalness and diversity.

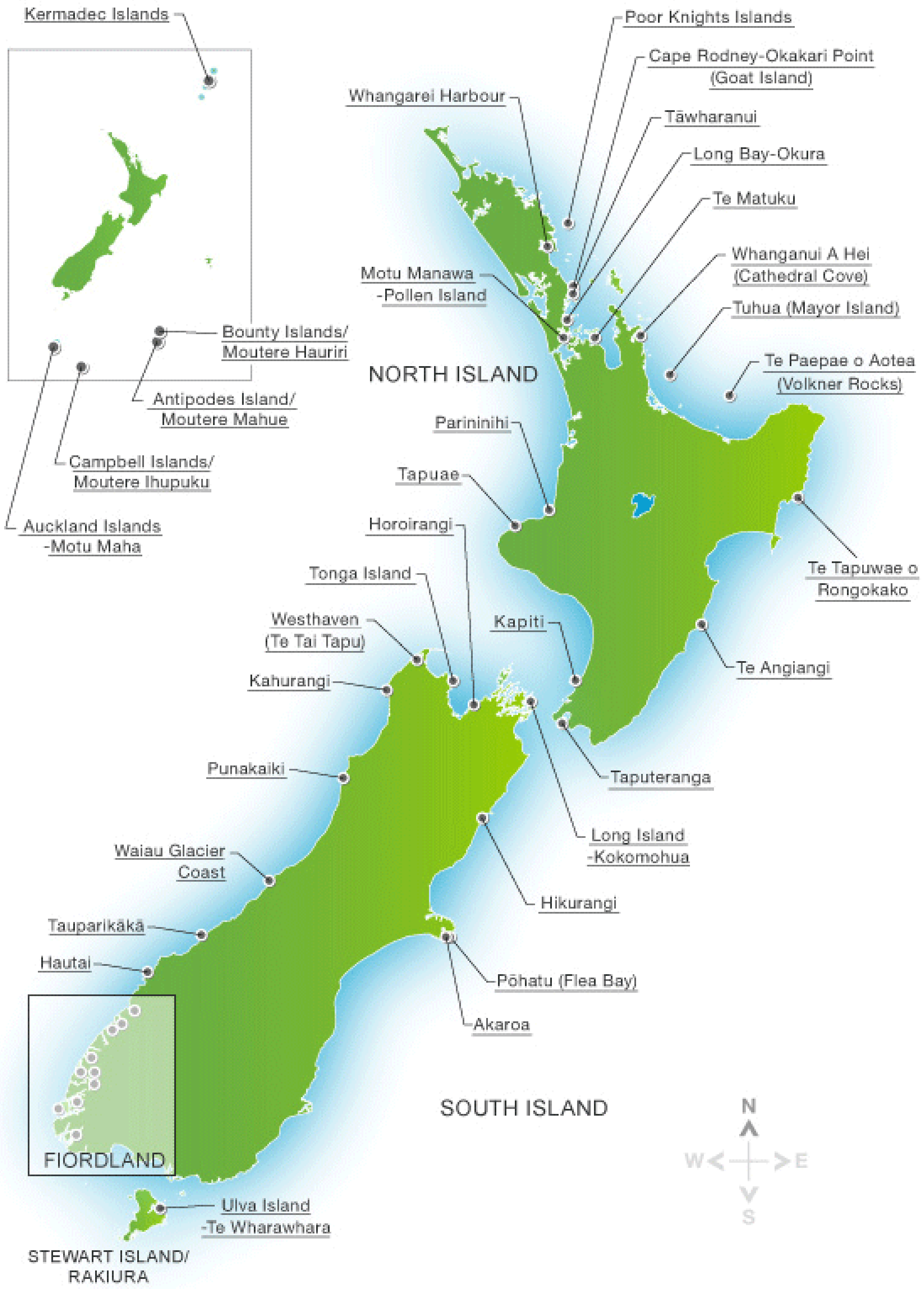
5.3.2 Marine Protected Areas

Protected Natural Areas are put in place for the conservation of biodiversity. They receive varying degrees of protection and are managed under six main pieces of legislation; the Conservation Act 1987, National Parks Act 1980, Reserves Act 1977, Wildlife Act 1953, Marine Reserves Act 1971, and the Marine Mammals Protection Act 1978. Protected Natural Areas may also be established under separate legislation; for example, the Kaikōura Marine Management Area is managed under the Kaikōura (Te Tai ō Marokura) Marine Management Act 2014 and contains a Marine Reserve, whale sanctuary, New Zealand fur seal sanctuary, and fisheries management areas.

New Zealand has three levels of marine protection; Type 1 and Type 2 Marine Protected Areas and 'Other' Marine Protection Tools. Type 1 Marine Protected Areas provide the highest level of marine protection and cover Marine Reserves (as established under the Marine Reserves Act 1971). All extractive activities are prohibited within the boundaries of a Marine Reserve. Type 2 Marine Protected Areas are established outside of the Marine Reserves Act and provide protection from adverse effects of fishing. They include Marine Protected Areas, Marine Parks, Marine Management Areas, Mātaitai, and fisheries closures. 'Other' Marine Protection Tools do not protect sufficient biodiversity to meet the Type 1 and Type 2 protection standards. Examples of 'Other' Marine Protection Areas include Benthic Protection Areas, Seamount Closures, Marine Mammal Sanctuaries and customary management areas (DOC, 2017).

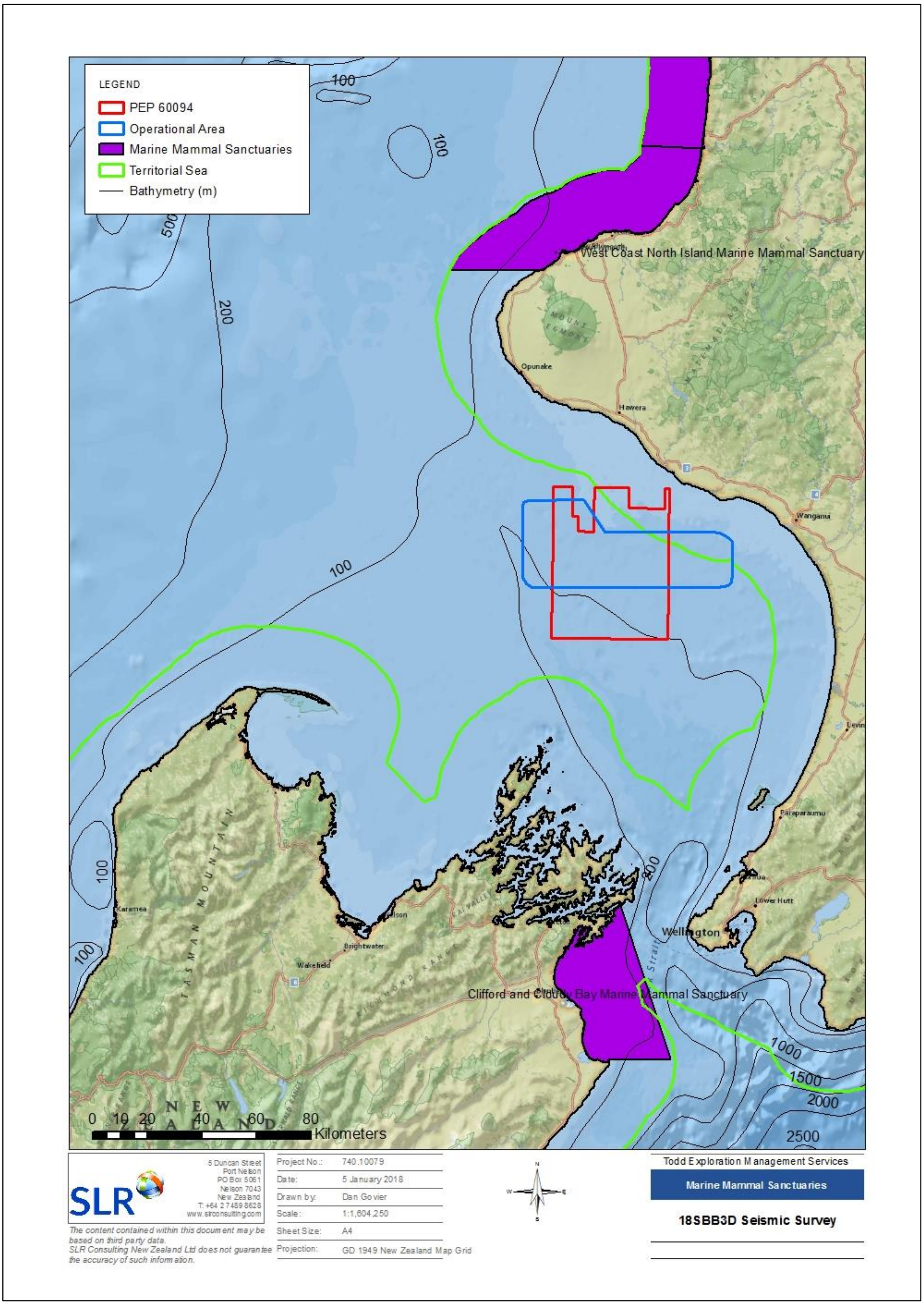
There are no Marine Protected Areas inshore of the Operational Area. The closest Marine Protected Areas are the Tapuae Marine Reserve, Parininihi Marine Reserve, the West Coast North Island Marine Mammal Sanctuary located north of Cape Egmont, the Clifford and Cloudy Bay Marine Mammal Sanctuary in the Cook Strait region, and the Kapiti Marine Reserve located on the Kapiti Coast in the lower South Taranaki Bight (**Figure 17** and **Figure 18**). However, these areas will not be influenced by the survey.

Figure 17 New Zealand Marine Reserves



Source: http://www.doc.govt.nz/nature/habitats/marine/marine-reserves-a-z/marine-reserves-map/

Figure 18 Marine Mammal Sanctuaries



5.3.3 New Zealand Marine Environmental Classification

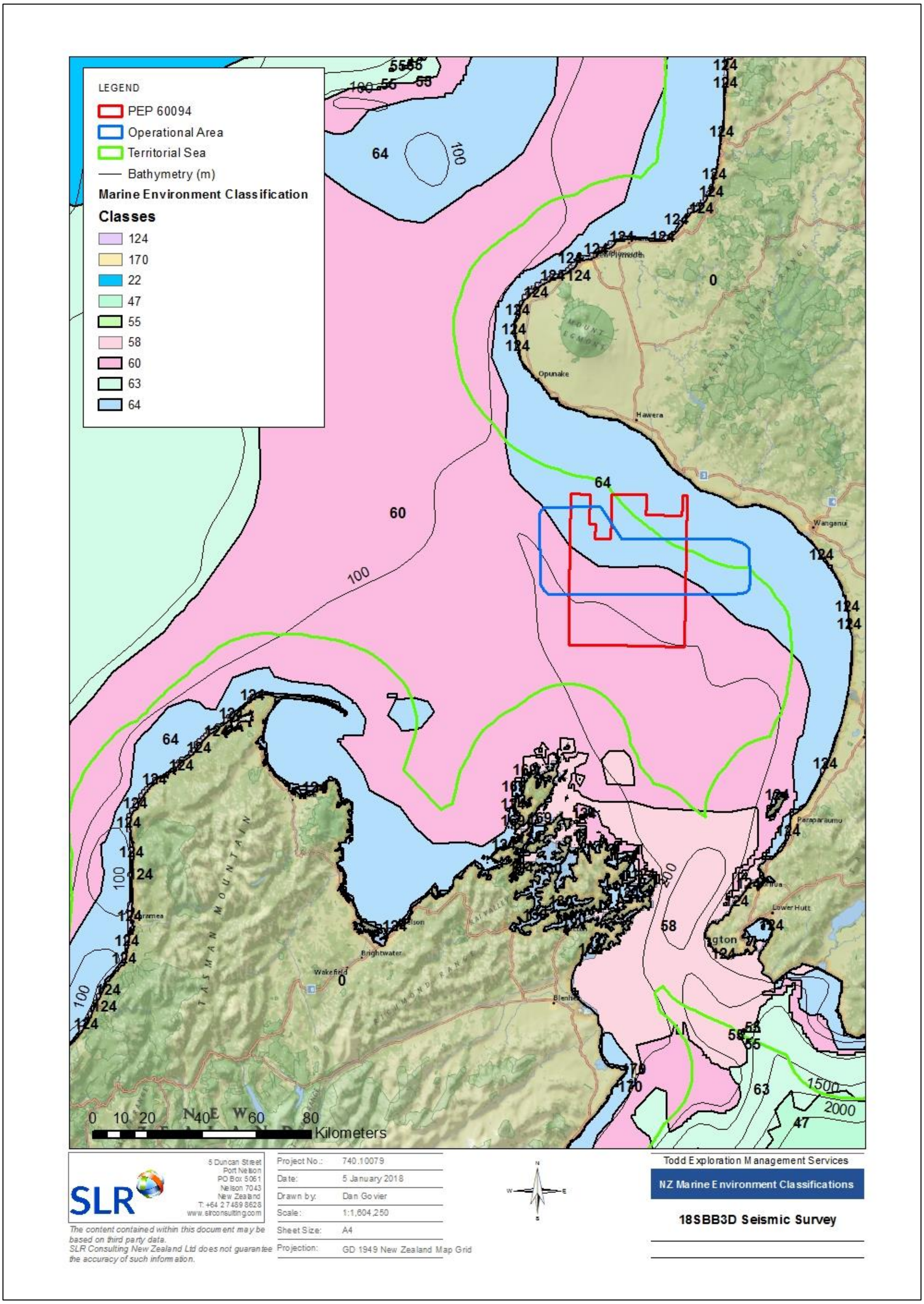
The New Zealand Marine Environment Classification covers New Zealand's CMA and EEZ and provides a spatial framework for structured and systematic management. Geographic domains are divided into classes that have similar environmental and biological characters (Snelder et al., 2005). Classes are characterised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

The Operational Area consists of Class 60 and 64 characteristics (**Figure 19**). These classes are described in further detail below following the definitions by NIWA (Snelder et al., 2005).

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

Class 64 represents shallow waters (mean = 38 m). Here seabed slopes are low but orbital velocities are moderately high and the annual variation of sea surface temperature is high. Chlorophyll-*α* reaches its highest average concentration in this class. Commonly occurring fish species are red gurnard, snapper, john dory, trevally, leather jacket, barracouta and spiny dogfish. Arrow squid are also frequently caught in trawls. The most commonly represented invertebrate families are Veneridae, Mactridae, and Tellinidae.

Figure 19 New Zealand Marine Environmental Classifications around the Operational Area



5.3.4 Sensitive Environments (EEZ & Continental Shelf Regulations)

The Ministry for the Environment (in consultation with NIWA) has identified 13 sensitive biogenic environments. These environments are described in Schedule 6 of the EEZ and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (EEZ Regulations). The 'sensitivity' of an environment is defined as the tolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery from damage sustained as a result of an external factor (MacDiarmid et al., 2013). Rarity of a habitat was taken into account when considering the tolerance, as the likelihood of a population of habitat being damaged by an external factor increases with increasing rarity (i.e. a rare habitat has a lower tolerance rating).

Table 19 provides details on the environments considered sensitive under the EEZ Regulations and the indicators used to identify their existence.

Table 19 Schedule 6 Sensitive Environment Definitions

Sensitive Environment	Indicator of existence of sensitive environment
Stony coral thickets or reefs	A stony coral reef or thicket exists if: • A colony of a structure-forming species covers 15% or more of the seabed in a visual imaging survey of 100 m² or more; or • A specimen of a thicket-forming species is found in two successive point samples; or • A specimen of a structure-forming species is found in a sample collected using towed gear.
Xenophyophore beds	A xenophyophore bed exists if average densities of all species of xenophyophore found (including fragments) equal or exceed one specimen per m² sampled.
Bryozoan thickets	A bryozoan thicket exists if: • Colonies of large frame-building bryozoan species cover at least 50% of an area between 10 m² and 100 m²; or • Colonies of large frame-building bryozoan species cover at least 40% of an area that exceeds 10 km²; or • A specimen of a large frame-building bryozoan species is found in a sample collected using towed gear; or • One or more large frame-building bryozoan species is found in successive point samples.
Calcareous tube worm thickets	A tube worm thicket exists if: • One or more tube worm mounds per 250 m² are visible in a seabed imaging survey; or • Two or more specimens of a mound-forming species of tube worm are found in a point sample; or • Mound-forming species of tube worm comprise 10% or more by weight or volume of a towed sample.
Chaetopteridae worm fields	A chaetopteridae worm field exists if worm tubes or epifaunal species: • Cover 25% or more of the seabed in a visual imaging survey of 500 m² or more; or • Make up 25% or more of the volume of a sample collected using towed gear; or • Are found in two successive point samples.
Sea pen fields	A sea pen field exists if: • A specimen of sea pen is found in successive point samples; or

Sensitive Environment	Indicator of existence of sensitive environment
	• Two or more specimens of sea pen per m² are found in a visual imaging survey or a survey collected using towed gear.
Rhodolith (maerl) beds	A rhodolith bed: • Exists if living coralline thalli are found to cover more than 10% of an area in a visual imaging survey; or • Is to be taken to exist if a single specimen of a rhodolith species if found in any sample.
Sponge gardens	A sponge garden exists if metazoans of classes Demospongiae, Hexactinellida, Calcerea, or Homoscleromorpha: • Comprise 25% or more by volume or successive point samples; or • Comprise 20% or more by volume of any sample collected using towed gear; or • Cover 25% or more of the seabed over an area of 100 m² or more in a visual imaging survey.
Beds of large bivalve molluscs	A bed of large bivalve molluscs exists if living and dead specimens: • Cover 30% or more of the seabed in a visual imaging survey; or • Comprise 30% or more by weight or volume of the catch in a sample collected using towed gear; or • Comprise 30% or more by weight or volume in successive point samples.
Macro-algae beds	A macro-algae bed exists if a specimen of a red, green, or brown macro-algae is found in a visual imaging survey or any sample.
Brachiopods	A brachiopod bed exists if one or more live brachiopods: • Are found per m² sampled using towed gear; or • Are found in successive point samples.
Deep-sea hydrothermal vents	A sensitive hydrothermal vent exists if a live specimen of a known vent species is found in visual imaging survey or any sample. See Schedule 6 for a list of known vent species.
Methane or cold seeps	A methane or cold seep exists if a single occurrence of one of the taxa listed in Schedule 6 is found in a visual imaging survey or any sample.

Bivalve beds may create complex biogenic structures in an otherwise homogenic habitat, resulting in modification of the surrounding habitat and communities. In New Zealand, bivalve beds are mainly found in water depths less than 250 m on the continental shelf, with common species including horse mussels, scallops and dredge oysters. They have been reported to be particularly well represented off the North Island's west coast out to mid-shelf depths (MacDiarmid et al., 2013). Bivalve beds have been recorded within, and in close proximity to, the Operational Area, as has bivalve rubble in the form of shell debris (Johnston, 2016). Beaumont et al. (2015) carried out dredge samples in close proximity to the Operational Area (as part of the Trans-Tasman Resources consent application process), and reported bivalves in the majority of dredges including small and large dog cockles (*Glycymeris modesta* and *Tucetona laticostata* respectively), and hairy mussels (*Mesopeplum convexum*).

The presence of live and dead brachiopods increases habitat complexity (MacDiarmid et al., 2013). Brachiopods occur throughout New Zealand, predominantly on hard substrates in areas that experience significant water movements and are free of fine sediments. While they have been found at all water depths, brachiopods tend to prefer depths less than 500 m; however, a large number of species have been recorded in water depths in excess of 1,000 m (MacDiarmid et al., 2013). Diverse or numerically abundant brachiopod assemblages have not been reported for the Taranaki Bight (MacDiarmid et al., 2013); however, Beaumont et al. (2015) did record brachiopods in dredge samples in close proximity to the Operational Area, mainly in water depths around 50 – 70 m. Johnston (2016) did not report brachiopods within, or in close proximity to, the Operational Area.

Habitat forming bryozoans are most commonly found in temperate continental shelf environments where there is suitable stable substrate and fast consistent water movement. Within New Zealand bryozoans are particularly abundant and diverse (MacDiarmid et al., 2013). Bryozoan thickets have been reported by Johnston (2016) in close proximity to the Operational Area. Johnston (2016) has also reported catches of bryozoan rubble within the Operational Area. A number of species that form significant habitats, including new records for the South Taranaki Bight, were recorded in close proximity to the Operational Area by Beaumont et al. (2015); however, abundance estimates showed a general trend of relatively low bryozoa abundance, with a high species richness in water depths of 60 – 80 m (Beaumont et al., 2015). Beaumont et al. (2013) reported byrozoans to be the primary biogenic structure in offshore South Taranaki Bight environments.

Calcareous tube worms can form dense three-dimensional mosaics across the seabed; known as thickets or mounds. The species *Galeolaria hystrix* is the best described example of mound-forming tube worms in New Zealand, and can be found from the Taranaki Coast down to Stewart Island (MacDiarmid et al., 2013). The distribution of calcareous tube worm thickets in Taranaki as reported by Johnston (2016) appears to be restricted to shallow inshore coastal waters. The Taranaki Bight was not reported by MacDiarmid et al. (2013) to be a particularly important area for calcareous tube worms. Based on the reported literature, calcareous tube worms are unlikely to be present within the Operational Area; however, based on the reasonably inshore nature of this survey, calcareous tube worms may be in close proximity to the boundaries of the Operational Area.

Chaetopteridae tube worms belong to a family of filter-feeding polychaetes that form burrows in soft sediments (Johnston, 2016). Little is known of their role in New Zealand. The Taranaki Bight was not identified by MacDiarmid et al. (2013) as an area of importance for chaetopteridae tube worms. Johnston (2016) reported a number of catches of chaetopteridae tube worms off Cape Egmont and within the South Taranaki Bight. Based on the records presented in Johnston (2016), chaetopteridae tube worms may be present within the Operational Area; however, Johnston (2016) suggests a more western distribution.

The distribution of deep-sea hydrothermal vents is related to tectonic plate boundaries, with New Zealand deep-sea hydrothermal vents forming at the subduction zone of the Pacific Plate under the Australian Plate (MacDiarmid et al., 2013). This occurs to the north of New Zealand well away from the Operational Area.

Macro-algae beds occupy areas of hard rocky substrate from the photic zone (where light reaches) down to depths of 200 m. Small foliose brown, red and green algae, as well as large brown algae/kelp form dense beds and are important components of the reef ecosystems (MacDiarmid et al., 2013). While MacDiarmid et al. (2013) reported macro-algae beds are present throughout New Zealand's EEZ, no specific Taranaki sites were mentioned. There were no reports of red, brown or green macro-algae beds within the Operational Area by Johnston (2016) however, based on the reasonably inshore nature of this survey, macro-algae beds may be inshore from the boundaries of the Operational Area. This is further emphasised by Beaumont et al. (2015) who reported the majority of catches of algae to occur in inner shelf areas where rocky outcrops were present, with little to no algae collected from deeper offshore habitats. Small foliose red algae was however observed in still photographs further offshore where it was growing on bivalve shell debris (Beaumont et al., 2015).

Methane or cold seeps occur when methane-rich fluids escape into the water column from the underlying sediments. Active seeps are usually associated with gas hydrates in the Gas Hydrate Stability Zone; typically in the upper 500 m of sediments beneath the seabed in water depths of at least 500 m (MacDiarmid et al., 2013). Active and relict cold seeps have been confirmed at the Hikurangi Margin on the North Island's east coast (MacDiarmid et al., 2013). There have been no cold seeps identified in the Taranaki Basin (Johnston, 2016). Furthermore, it is unlikely that cold seeps will be present within the Operational Area due to its shallow inshore nature.

Rhodolith beds form structurally and functionally complex habitats (MacDiarmid et al., 2013). Little is known of the location of rhodolith beds in New Zealand; however, known locations are typically coastal in nature (MacDiarmid et al., 2013). The preferred habitat of rhodoliths is characterised by strong currents within the photic zone, particularly around the margins of reefs or elevated banks (MacDiarmid et al., 2013). Rhodolith beds have not been reported as present within the Operational Area, or the South Taranaki Bight (Johnston, 2016).

Sea pens occur on fine gravels, soft sand, mud, and the abyssal ooze, in areas where turbulence is unlikely to dislodge their anchoring peduncle but where a current exists to ensure a continuous flow of food (MacDiarmid et al., 2013). Sea pens have not been reported as present within the Operational Area (Beaumont et al., 2015; Johnston, 2016); however, the species *Virgularia gracillima* is widespread throughout the offshore soft sediment communities of the wider Taranaki Bight (e.g. SLR, 2017, 2017a, 2017b, 2017c).

Sponges are found across a variety of environments such as shallow coastal rocky reefs, seamounts, hydrothermal vents and oceanic ridges. In New Zealand waters demosponges dominate the shelf and coastal area in water depths down to 250 m, while deeper waters are dominated by the hexactinellid (glass) sponges. Examples of known locations of sponge gardens in New Zealand include the North Taranaki Bight (MacDiarmid et al., 2013), with the Sugar Loaf Islands Marine Protection Area particularly well known for diverse sponge communities (MacDiarmid et al., 2013). Beaumont et al. (2015) reported catches of mainly demospongiae, with one species of calcareous sponge also recorded. The highest abundance and species richness of sponges were recorded in water depths of approximately 60 – 80 m (Beaumont et al. 2015). Although there is potential for sponge gardens to be present in the Operational Area, there are no records in Johnston (2016) for the Operational Area.

Coldwater corals include the Scleractinia (stony corals), Octocorallia (soft corals), Antipatharia (black corals), and Stylasteridae (hydrocorals). Stony corals provide the most complex habitats and can form extensive reefs or thickets (MacDiarmid et al., 2013). **Figure 14** provides distribution maps of corals in the South Taranaki Bight. No stony corals or thickets have been recorded in the Operational Area (Johnston, 2016).

Xenophyophore beds are often mistakenly identified as broken and decaying parts of other animals. Seven species have been recorded in New Zealand, three of which are endemic (MacDiarmid et al., 2013). Xenophyophores are particularly abundant below areas of high surface productivity. Sampling locations in New Zealand include the eastern, northern, and western continental slopes, and on the Chatham Rise in depths of 500 – 1,300 m (as referenced in MacDiarmid et al., 2013). Johnston (2016) has not reported any xenophyophore beds within, or in close proximity to the Operational Area. The closest recorded xenophyophore bed to the Operational Area was in water depths in excess of 1,200 m off the North Taranaki Bight (Johnston, 2016).

5.4 Cultural Environment

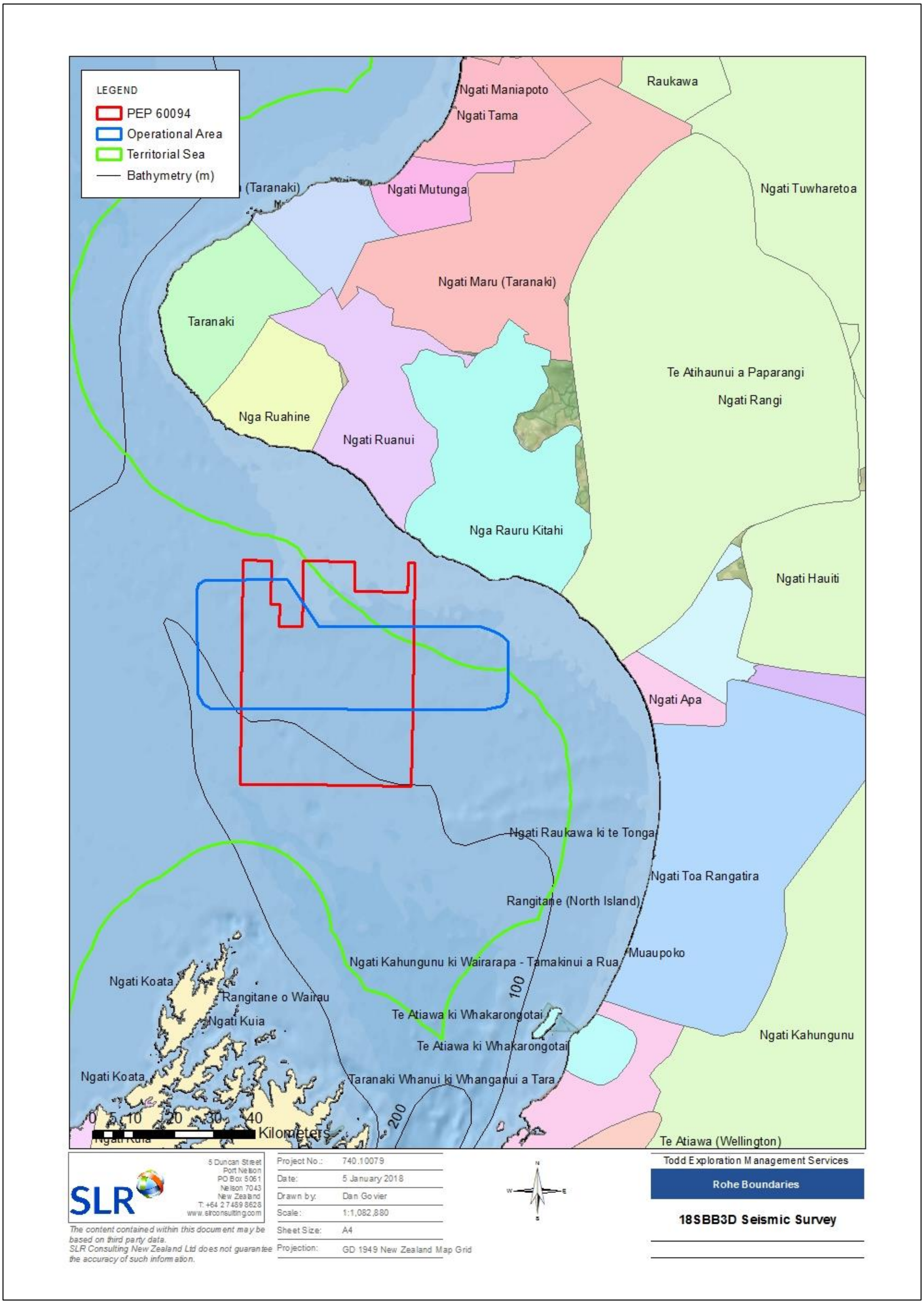
The marine environment is of high cultural value to Māori. Estuaries and coastal waters are particularly important as a source of kaimoana (seafood), and Māori have a deep spiritual connection with whales and dolphins. Although all whales have significant cultural importance in New Zealand, sperm whales in particular are commonly recognised as taonga (treasures) to Māori. In addition to this, the marine environment is also typically regarded as a sacred pathway and provides a means of transport and communication (Nga Uri O Tahinga Trust, 2012). Kaitiakitanga (guardianship) of the natural environment is central to Māori belief systems and serves to protect wahi tapu (sacred places or sites) and taonga. Māori first arrived in Taranaki between 1250 and 1300 AD. Many of the original Taranaki iwi (tribes) migrated south in the early 1800's as a result of invasions from Waikato war parties. The Taranaki coast was the scene of many battles and now contains numerous urupa (burial sites) and other wahi tapu sites, including large pā (fortified villages), tauranga waka (canoe landing places), and traditional mahinga kai (natural resources). The Operational Area is of relevance to six iwi (from Cape Egmont to Foxton) as listed in **Table 20** and depicted in **Figure 20**. A brief overview of these iwi, their rohe (area of interest) and any marine attributes of particular cultural interest are provided in **Table 20**.

Table 20 Iwi interests in the vicinity of the Operational Area

Iwi (tribal group)	Region/s	Coastal Statutory Acknowledgement Areas	Taonga (treasured) species*	Further comments
Te Kahui o Taranaki Trust	Taranaki	Nga Motu; Paritutu to Oakura River; Oakura River to Hangatahua River; and Kapoaiaia River to Moutoti River (Taranaki Iwi Claims Settlement Act, 2016).	Traditional kaimoana e.g. paua, kina, kōura (crayfish), kūkū, pūpū (molluscs), ngākihi (limpets), pāpaka, toretore (sea anemones), tāmure (snapper), kahawai, pātiki, and mako (shark).	The CMA is known to Taranaki iwi as Ngā Tai a Kupe (the shores and tides of Kupe) and contains a number of kaimoana reefs, wāhi tapu sites and tauranga waka. Taranaki Iwi places substantial historical and spiritual importance in the Ngā Motu (Sugar Loaf) Islands (Taranaki Iwi Trust, 2013). The Tapuae Marine Reserve is encompassed by the Taranaki Iwi rohe.
Ngāruahine	Taranaki	Taungatara Stream; Kapuni Stream; Kaupokonui Stream; Ohunuku Otakeho; Waingongoro River; and Puketapu (Nga Ruahine, 2014).	Traditional kaimoana (TRC, 2010).	Collectively made up of various hapu, including Kanihi-Umutahi, Okahu-Inuawai, Ngati Manuhiaka, Ngati Tu, Ngati Haua and Ngati Tamaahuroa-Titahi (Nga Ruahine, 2014).
Ngāti Ruanui	Taranaki Whanganui	Tangahoe River; Patea River; Whenuakura River; and Te Moananui a Kupe o Ngāti Ruanui (the CMA) (Ngāti Ruanui, 2001).	Hapuku, kahawai, kane, marari (butterfish), moki, paraki (smelt), para (frostfish), pātiki, patukituki (red cod), pioke (rig), reperepe (elephantfish), tuna, kaeo (sea tulip), koeke (shrimp), wheke (octopus), koiro (conger eel), koura (crayfish), kaunga (hermit crab), papaka parupatu (mud crab), pāpaka (paddlecrab), kotere (sea anemone), rore (sea cucumber), patangatanga (starfish), kina, kūkū (mussels), paua, pipi, pupu (snails), purimu (surf clams), tuangi (cockles), tuatua, waharoa (horse mussel), waikaka (mud snail), tio (oyster), and tupa (scallop) (Ngāti Ruanui, 2001).	The resources found within Te Moananui a Kupe have, since time immemorial, provided the people of Ngāti Ruanui with a constant supply of food resources. The hidden reefs provided koura, paua, kina, pupu, papaka, pipi, tuatua and many other species of reef inhabitants. Hapuku, moki, kanae, mako and patiki swim freely between the many reefs that can be found stretching out into the Ngāti Ruanui coastline. Ngāti Ruanui are partners in the South Taranaki Reef Life project. This project aims to discover and document the subtidal rocky reef communities that are found in the South Taranaki Bight (Curious Minds, 2017).
Ngā Rauru Kītahi	Manawatu/ Whanganui	Nukumaru Recreation Reserve; Tapuarau Conservation Area; Patea River; Whenuakura River; and Waitotara River (Ngā Rauru Kiitahi, 2003).	Traditional Kaimoana.	Along the coastline of Ngā Rauru's rohe lay a number of pa, kainga and marae, including Rangitaahwi and Wai-o-Turi which remain today (Ngā Rauru Kiitahi, 2003). Ngā Rauru Kiitahi gathered food over a large area of coastal South Taranaki and there are many sites of cultural and spiritual significance to this iwi along their coastal rohe (TRC, 2016).
Whanganui Iwi	Manawatu/ Whanganui	Whanganui iwi have not yet received a historical settlement from the Crown, therefore no statutory acknowledgement rights have been formalised.	Freshwater species that spawn or have a larval development phase in marine waters (e.g. bully species, inanga (whitebait), and tuna (eels)), and marine species that feed in freshwater (e.g. kanae (mullet), pātiki (flatfish/flounder), and kahawai) (Waitangi Tribunal, 1999).	The Te Awa Tupua (the Whanganui River) holds particular spiritual significance and its life force is considered to extend well into the coastal zone beyond the river mouth (Waitangi Tribunal, 1999). Fishing villages were built on the banks of the estuary, with permanent pā sites further up the river.
Ngati Apa	Manawatu/ Whanganui	Whangaehu River; Turakina River; Rangitikei River; Herewahine (a culturally significant sand dune linked to an ancestral sighting of stranded sperm whales); and Pukauhu (a shag breeding colony near the Turakina River).	Traditional Kaimoana.	The coastline was traditionally used as a highway and many coastal resources were harvested to provide sustenance to the iwi. Sea fishing was a major activity particularly in the summer months when fishing stations and Tauranga waka were established at the river mouths. The year round collection of shellfish also occurred along the coast.

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

Figure 20 Rohe boundaries in the Vicinity of the Operational Area



5.4.1 Customary Fishing and Iwi Fisheries Interests

The collection of kaimoana is a fundamental way of Māori life. For coastal hapū, kaimoana is often vital to sustain the mauri (life force) of tangata whenua, and provides an important food source for whānau (family) and hospitality to manuhiri (guests). The ability to provide reasonable amounts of these foods is a marker of a tribe's mana (power/status) (Tainui Waikato, 2013). There are a number of marine species which iwi value highly such as: snapper, kahawai, blue cod, flat fish, sharks, grey mullet, sea urchin (kina), scallops, mussels, paua, pipi, toheroa, cockles and tuatua. 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 only passed on to those who will look after it.

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

New Zealand iwi also have customary fishing rights provided for under the Fisheries (Kaimoana Customary Fishing) Regulations 1998. These regulations stem from the Treaty of Waitangi (Fisheries Claims) Settlement Act (1992) and are separate, and in addition to, the commercial fisheries assets described above. Under these regulations 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).

Tangata Kaitiaki/Tiaki are individuals or groups (appointed by the local Tangata Whenua and confirmed by the Minister of Fisheries) who can 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. There are three types of customary fishing rights recognised under the legislation: Rohe Moana, Mātaitai and Taiapure; these are described below and the locations subject to customary rights are illustrated in **Figure 21**.

5.4.1.1 Rohe Moana

A rohe moana is an area where kaitiaki are appointed for the management of customary kaimoana collection within their rohe under the Fisheries (Kaimoana Customary Fishing) Regulations (1998). Rohe moana allow for management controls to be established, including the issue of permits for customary take, the establishment of penalties for management breaches, and for restrictions to be established over fisheries areas to prevent stock depletion or overexploitation. The purpose of the rohe moana is for the better provision for the recognition of Rangitiratanga (sovereignty) and of the right secured in relation to fisheries by Article II of the Treaty of Waitangi. A number of rohe moana occur in the vicinity of the Operational Area as listed below:

- Ngāti Haumia Rohe Moana (just south of Cape Egmont);
- Titahi-Ngaruahine Rohe Moana (just south of Cape Egmont); and
- Te Atihaunui a Paparangi and Nga Rauru Rohe Moana (extend southwest from Whanagnui).

An additional rohe moana, the 'Deepwater Customary Pataka' has been proposed. This pataka (food supply) represents an agreement between 16 iwi groups, Sealords and Te Ohu Kaimoana to facilitate customary fishing in deeper waters of the South Taranaki Bight. In essence, the Sealords fleet will be able to take fish for customary purposes and supply the customary catch to relevant iwi interest groups for customary events such as tangi.

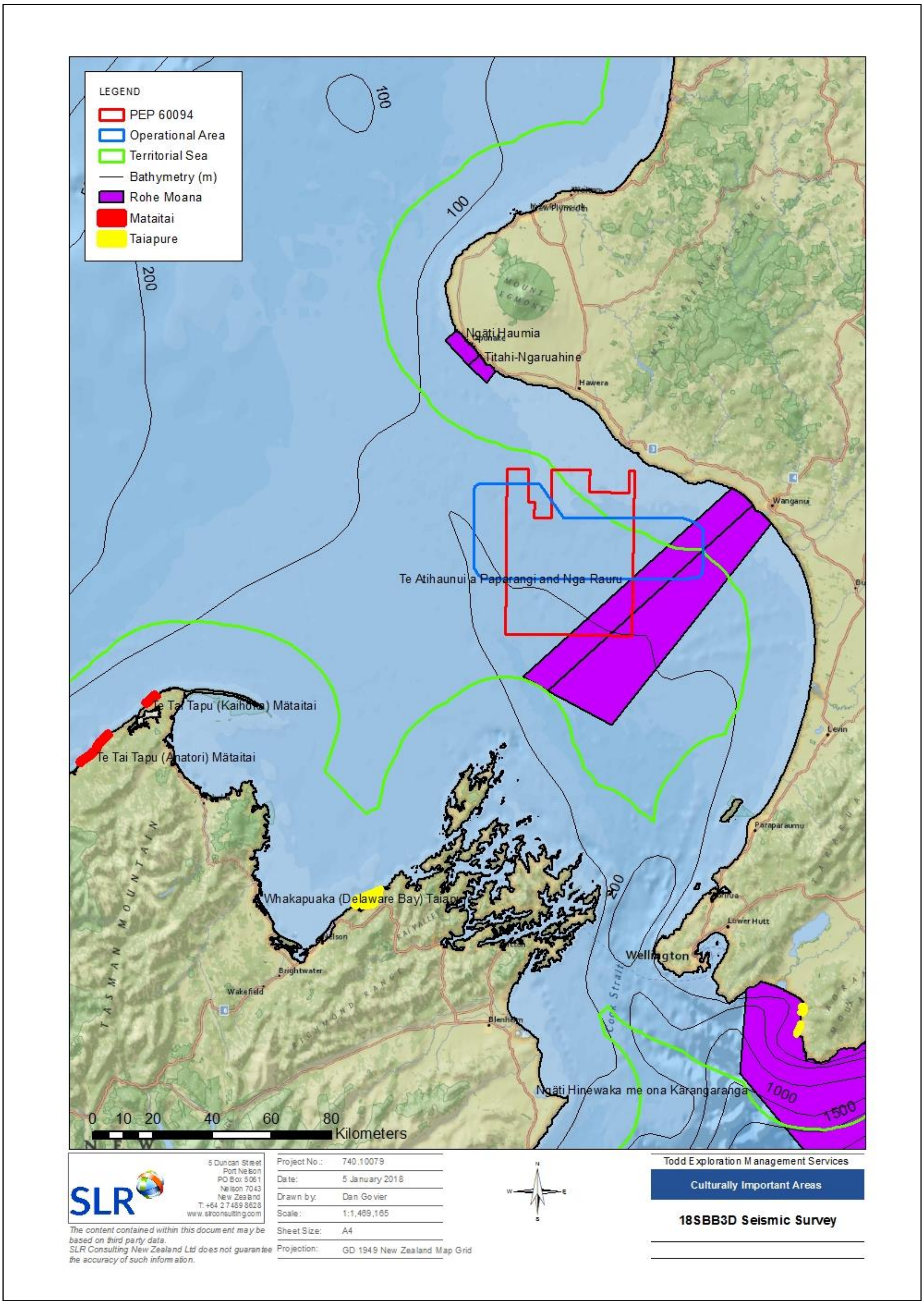
5.4.1.2 Mātaitai Reserves

Mātaitai Reserves are traditional fishing grounds established for the purpose of recognising and providing kaimoana collection and customary management practices. Commercial fishing is prohibited within a Mātaitai Reserve; however, recreational fishing may continue. Tangata whenua are able to exercise their customary rights through a customary fishing permit under the Fisheries (Amateur Fishing) Regulations 1986. There closest Mātaitai Reserve is 115 km to the southwest of the Operational Area.

5.4.1.3 Taiapure

A Taiapure can be put in place under the Fisheries Act (1996) and Fisheries (Kaimoana Customary Fishing) Regulations (1998) to allow local management of an area. These areas are required to be significant to an iwi or hapū as either a food source or for cultural or spiritual reasons. A Taiapure allows tangata whenua to be involved in the management of both commercial and non-commercial fishing in their area but does not stop all fishing. There closes Taiapure is 110 km to the south-southwest of the Operational Area.

Figure 21 Mataitai, Taiapure and Rohe Moana in the Vicinity of the Operational Area



5.4.2 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 and provides for the recognition of the customary rights of iwi, hapū and whānau in the common marine and coastal area (the area between mean high water springs and the outer limits of the territorial sea). Iwi, hapū or whānau groups can get recognition of two types of customary interest under the Marine and Coastal Area Act, these are 1) customary marine title, and 2) protected customary rights. The recognition that these two types of customary interest provide are summarised by the Department of Justice (2017) as outlined below.

Customary Marine Title

A Customary marine title recognises the relationship of an iwi, hapū or whānau with a part of the common marine and coastal area. Free 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’ which lets the group say yes or no to activities that need resource consents or permits in the area;
- A ‘conservation permission right’ which lets the group say yes or no to certain conservation activities in the area;
- The right to be notified and consulted when other groups apply for marine mammal watching permits in the area;
- The right to be consulted about changes to Coastal Policy Statements;
- A wāhi tapu protection right which lets the group seek recognition of a wāhi tapu and restrict access to the area if this is needed to protect the wāhi tapu;
- The ownership of minerals other than petroleum, gold, silver and uranium which are found in the area;
- The interim ownership of taonga tūturu found in the area; and
- The ability to prepare a planning document which sets out the group’s objectives and policies for the management of resources in the area.

Protected Customary Rights

Protected customary rights can be granted for a customary activity like collecting hāngi stones or launching waka in the common marine and coastal area.

If your group has a protected customary right recognised, you don’t 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 your protected customary right.

Table 21 outlines the applications which have been made under the Marine and Coastal Area (Takutai Moana) Act 2011 and that are relevant to the Operational Area. Note that the majority of these applications are still being processed and that engagement was only undertaken with applicants in Taranaki where there is a direct overlap between the area of application and the Operational Area.

Table 21 Applications under the Marine and Coastal Area (Takutai Moana) Act 2011

Applicant	Region	Recognition Sought	Application Area
Taranaki Iwi	North and South Taranaki	Customary Marine Title (CMT) & Protected Customary Rights (PCR)	Paritūtū to Rawa-o-Turi stream out to 12 M offshore
Ngāti Ruanui	South Taranaki	CMT and PCR	From Waingongoro River in the north, to Whenuakura River in the south, out to 12 M.
Ngā Hapū ō Ngāruahine	South Taranaki	CMT and PCR	Between the Taungatara and Waihi Rivers
Ngaa Rauru	South Taranaki	CMT and PCR	From Te Awanui-a-Taikehu (Patea River) in the north, to the Whanganui River in the south and out to 12 M.
Ngā Wariki Ngāti Apa	South Taranaki	CMT and PCR	The area from the coast abutting Motu Karaka in the North to the coast abutting Omarupapako in the south. The area covers all water from the coastline out to 12 M.
Ngāti Hāua Hapū, Ngāruahinerangi Iwi	South Taranaki	CMT	Between the mouth of the Raoa (Rawa) stream to the mouth of the Ōtakeho stream to 12 M.
Rakautaua 9 Whenua Topu Trust	Whanganui	CMT	The area from the mouth of the Whangaehu River, south to the mouth of the Turakina River. This area extends out 12 M offshore between these two points.
Te Awa Tupua and Nga Hapu me Nga Uri o Te Iwi o Whanganui	Whanganui	CMT and PCR	From Kai river in the north to the the Whangaehu river in the south, out to 12 M.
Te Patutokotoko	Whanganui	CMT and PCR	The area lies on the west coast of the North Island. It is bounded by the Kai Iwi River in the North and Lake Papaitonga in the south.
Rakautaua 1C Maori Reservation	Whanganui	CMT and PCR	Kaitoke stream to the Whangaehu river and out 12 M offshore.
Ngati Takihiku, Ngati Hinemata, Ngati Ngaronga	Manawatu	CMT and PCR	CMT: 2 km north of the Rangitikei River to 500 metres south of the Otaki River. PCR: From the Rangitikei River and south of the Manawatu River, out to 12 M.
Nga Hapu o Himatangi	Manawatu	CMT	The area from the Northern side of Te Puaha o Manawatu to the Southern Side of the Wangaehu awa, out to 12 M.
Rangitane o Manawatu	Manawatu	CMT and PCR	Northern bank of the Rangitikei River to the southern bank of the Manawatu River, out to12 M.
Muaupoko	Manawatu	CMT	The area from the Northern Bank of the Mouth of the Manawatu River to the Southern bank of the mouth of the Waiwiri Stream. It extends to 12 M offshore between these two points.

5.5 Historic Environment

Based on a desktop study The Taranaki Regional Council has identified archaelogical sites of interest in their Coastal Marine Area (Dodd, 2012). A total of 1,874 archeoligical sites were identified, 183 of which are situated within 100 metres off the coast. Examples of archeological sites include canoe landings (areas of foreshore cleared of boulders), petroglyphs, shipwrecks, sunken aircraft, wharves and jetties, protective works for coastal erosion, coastal defence (e.g. concrete machine gun emplacements), anchorages (locations where specific ships anchored), shipbuilding yards, whaling stations, iron sand mining operations, oil prospecting sites and reclamations. Archealogical sites near the Operational Area include a power station, railway wharf, the town wharf, training walls, the Waitangi shipwreck and a 'pill box'.

There are at least 126 documented shipwrecks in the Taranaki region, of which 64 were wrecked prior to 1900. Of the remaining 62 vessels at least 8 were constructed prior to 1900. Of note are the *Gairloch* (1884-1903) at Ahu Ahu and the *Waitangi* (1889-1923) at Pātea. Any shipwrecks pre-dating 1900 have statutory protection under the Historic Places Act 1993 and cannot be modified or destroyed unless an authority has first been obtained from the New Zealand Historic Places Trust.

5.6 Socio-Economic Environment

5.6.1 Recreational Fishing

Marine recreational fishing is one of the most popular recreational past-times in New Zealand; a 2001 survey of most popular leisure activities placed fishing (marine and freshwater combined) as the fifth most popular recreational activity after walking, gardening, swimming, and exercising (Te Ara, 2017).

There are a number of recreational fishing and boating clubs throughout the Taranaki and Manawatū-Whanganui region, many of which host and administer fishing tournaments throughout the year.

Although the waters surrounding the Operational Area are not heavily fished, recreational fishing remains an important past-time for residents of the Taranaki and Manawatū-Whanganui regions. This coastline supports significant recreational fisheries, with popular target species including blue cod, gurnard, kahawai, snapper, red cod, tarakihi, trevally, crayfish and paua (Rob Greenaway & Associates, 2015).

Within the Taranaki region, areas close to New Plymouth and Cape Egmont are particularly well-fished during summer months, when vessels target pelagic game fish (including various species of tuna and marlin). Taranaki recreational fishermen are also increasingly venturing out to the edge of the continental shelf from New Plymouth to fish the canyon systems for deepwater species. Long-lining using kontikis and kites are popular along the exposed beaches of the North and South Taranaki Bight, as is surfcasting (MPI, 2017a). During the summer months recreational vessels could potentially be in parts of the Operational Area chasing pelagic game fish.

Recreational fishing activities occur throughout the Manawatū-Whanganui coastline, namely surfcasting, shellfish gathering, diving, fishing and boating. Boat fishing occurs throughout the marine area, although the majority of this activity occurs within 21 km from the shore (Rob Greenaway & Associates, 2015). Due to the exposed nature of this coastline, and presence of bars at the river mouths to main ports (i.e. Patea and Whanganui) making navigation difficult in rougher sea conditions, access to fishing areas along this coastline is restricted; for example the Patea River Bar is passable on approximately 80 days a year (Rob Greenaway & Associates, 2015). Some recreational fishing for grouper, rig and shark occurs outside of the 12 M limit, with the majority of fishing occurring between Ohawe and Waverly (Rob Greenaway & Associates, 2015).

Recreational diving opportunities within the South Taranaki Bight are limited to the North and South Traps (collectively referred to as the Waipipi Shoals), Kapiti and Mana Islands towards the south, and the Sugar Loaf Islands off New Plymouth. Inshore rocky reefs tend to offer limited diving opportunities due to generally turbulent conditions with poor visibility. Crayfish along this coastline are generally plentiful and of good size, while divers are easily able to collect their daily scallop limit in the Waipipi area (Rob Greenaway & Associates, 2015).

Shellfish gathering occurs throughout the intertidal zone, with specific gathering sites including gathering of tuatua between Whanganui and Waitotara, tuatua and cockles at the Waitotara River mouth, mussels off Ototoka Beach, and mussels south of Waiinu. Paua can be gathered around the Opunake area, south of Opunake there is limited paua habitat (Rob Greenaway & Associates, 2015).

5.6.2 Commercial Fishing

Ten Fisheries Management Areas (FMAs) have been implemented within New Zealand waters in order to manage the Quota Management System (**Figure 22**). These areas are regulated by the Ministry for Primary Industries. Over 1,000 fish species occur in New Zealand waters (Te Ara, 2017a); with the Quota Management System providing for the commercial utilisation and sustainable catch of 96 of these species. Species managed under the Quota Management System are divided into separate stocks, with each stock managed independently. The Operational Area straddles FMA8 (Central - Egmont) (**Figure 22**).

Finfish species caught within FMA8 are listed in **Table 22**, with the top five species, according to Total Allowable Commercial Catch (TACC) presented.

Table 22 Total Allowable Commercial Catch Allocations for Finfish in FMA8

FMA8	
Species	**TACC (tonnes)**
Snapper	1,300
Leatherjacket	1,136
Gurnard	543
School shark	529
Kahawai	520

MacDiarmid and Ballara (2016) provide further details on commercial fisheries occurring within the South Taranaki Bight based on MPI fisheries catch data. Catch data looks at all the fishing and landing events associated with a set of fishing trips that reported a positive catch or landing of any species within a set area. However, interpretation of these results when referring to the Operational Area needs to be done with caution as the MPI study area included the majority of the South Taranaki Bight; i.e. a significantly larger area than just the Operational Area.

Commercial fisheries in the South Taranaki Bight use a variety of methods including bottom trawling, mid-water trawling, set-netting, bottom long-lining, squid jigging, purse seining, trolling, potting/trapping, and drop lining. There are regulations prohibiting set-netting from the coast out to two nautical miles offshore in the area down to Hawera and trawling by vessels larger than 46 m is prohibited from an area just outside the CMA boundary. Set-netting is also prohibited from an area up to 7 M offshore unless an MPI fisheries observer is onboard (MacDiarmid & Ballara, 2016).

Bottom trawling was the most common fishing method in the South Taranaki Bight in the fishing years between 2006 and 2015, with mid-water trawling second most common and set-netting third. Trolling, drop lining, hand-lining, cod-potting, pole and line fishing, Danish seining, purse-seining, diving, dredging, fish trapping and hand gathering were all carried out within the South Taranaki Bight at relatively low levels (MacDiarmid & Ballara, 2016).

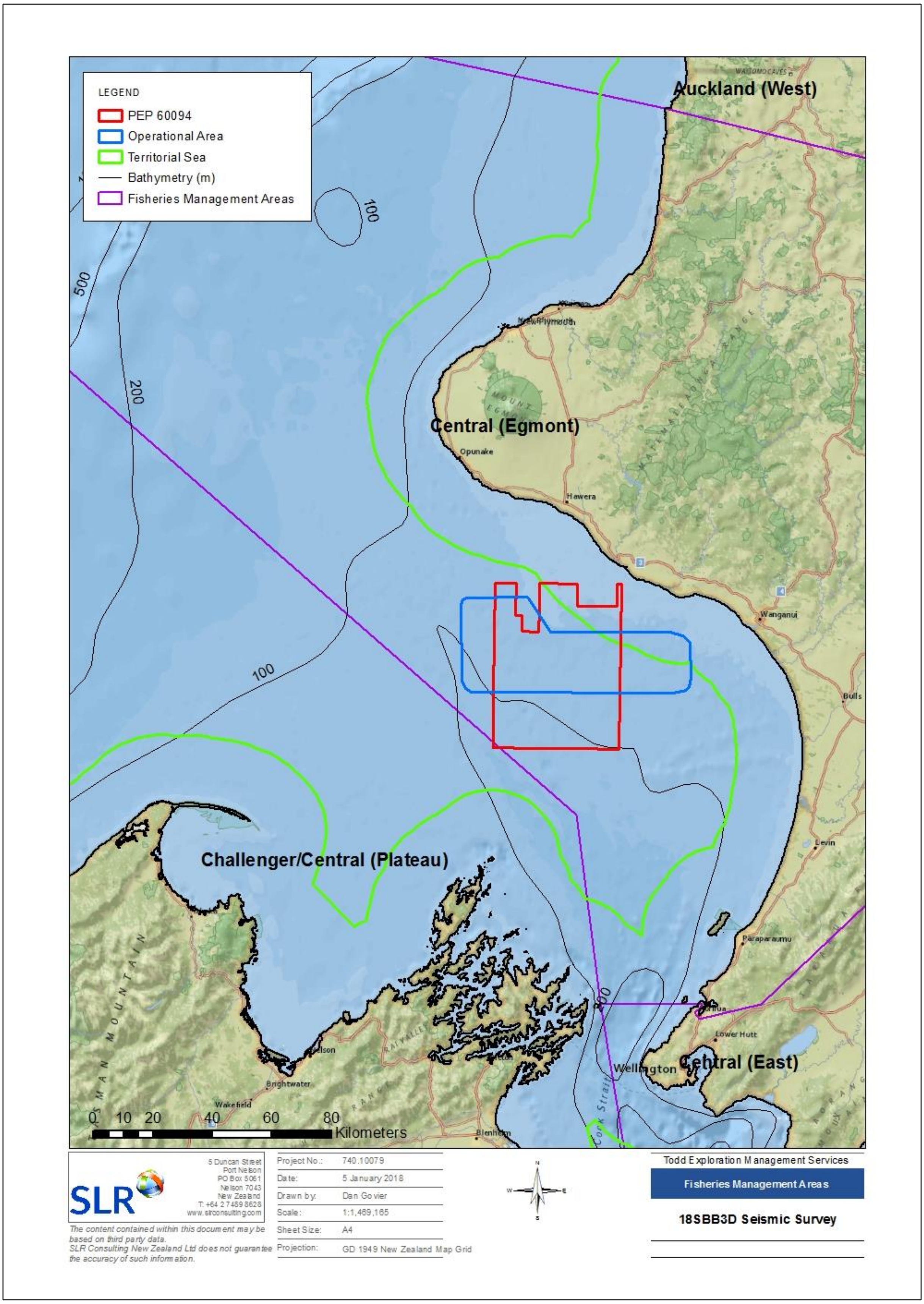
The highest overall level of fishing effort in the South Taranaki Bight occurs offshore of the coastline south of Whanganui, close to the shore north of Opunake, and close to shore north and south of Whanganui. The highest overall fishing effort occurs off the coastline between New Plymouth and Cape Egmont (north of the Operational Area), between Hawera Whanganui near the 50 m contour, and north of D'Urville Island (south of the Operational Area) (MacDiarmid & Ballara, 2016).

The distribution of total catch shows a different pattern to that of fishing effort. Total catch is dominated by a large, offshore midwater jack mackerel trawl fishery towards the west and south of the South Taranaki Bight (MacDiarmid & Ballara, 2016).

Target species varies based on the fishing method used. The main species caught by bottom trawls in the South Taranaki Bight is gurnard, with tarakihi, blue warehou, trevally, john dory, several species of flatfish, leather jacket, barracouta, and snapper also consistently caught (MacDiarmid & Ballara, 2016). Midwater trawling throughout the South Taranaki Bight mainly targets jack mackerel and barracouta. This type of fishing tends to occur in deeper water well beyond the 50 m depth contour parallel to the coast between Opunake and Whanganui (MacDiarmid & Ballara, 2016). Set-netting mainly targets rig, school shark, blue warehou, and flatfish, with smaller catches of butterfish, grey mullet, kahawai, and yellow-eyed mullet also occurring. Set-netting activities focus on the coastline around New Plymouth and between Hawera and Whangaui around the 50 m depth contour. Bottom longlining occurs mainly outside of the Operational Area targeting school shark, red gurnard, and hapuka/bass (MacDiarmid & Ballara, 2016).

Engagement with commercial fishers that use the South Taranaki Bight occurred prior to the survey commencing.

Figure 22 Fisheries Management Areas in the Vicinity of the Operational Area



5.6.3 Shipping

The small river port of Whanganui is the closest commercial port to the Operational Area and is located in the river-mouth of the Whanganui River. Whanganui Port provides docking facilities for smaller coastal freight vessels and commercial boats, with facilities including cargo handling, 580 lineal meters of wharf space and three warehouse buildings for storage use. The port currently has the capacity to accommodate vessels 51 meters in length (Whanganui, 2017). Access to the port is over a bar, making navigation into the port dangerous. Currently vessels with a draft of up to 4.2 m can enter/depart near high water (Dilley, 2016). The only commercial cargo vessel regularly using the facilities at Whanganui Port is the ‘Anatoki’; a general bulk cargo vessel that uses the port for shipping dolomite, logs, urea, and barley (Dilley, 2016). For recreational boat users there is a city wharf for mooring pleasure craft and a trailer boat ramp and trailer park) (Whanganui, 2017). Whanganui Port is currently in the discussion and planning stages of a ‘Port Revitalisation Project’, including the potential for a commercial ferry service between Whanganui Port and Motueka (Tasman district) (Whanganui, 2017a).

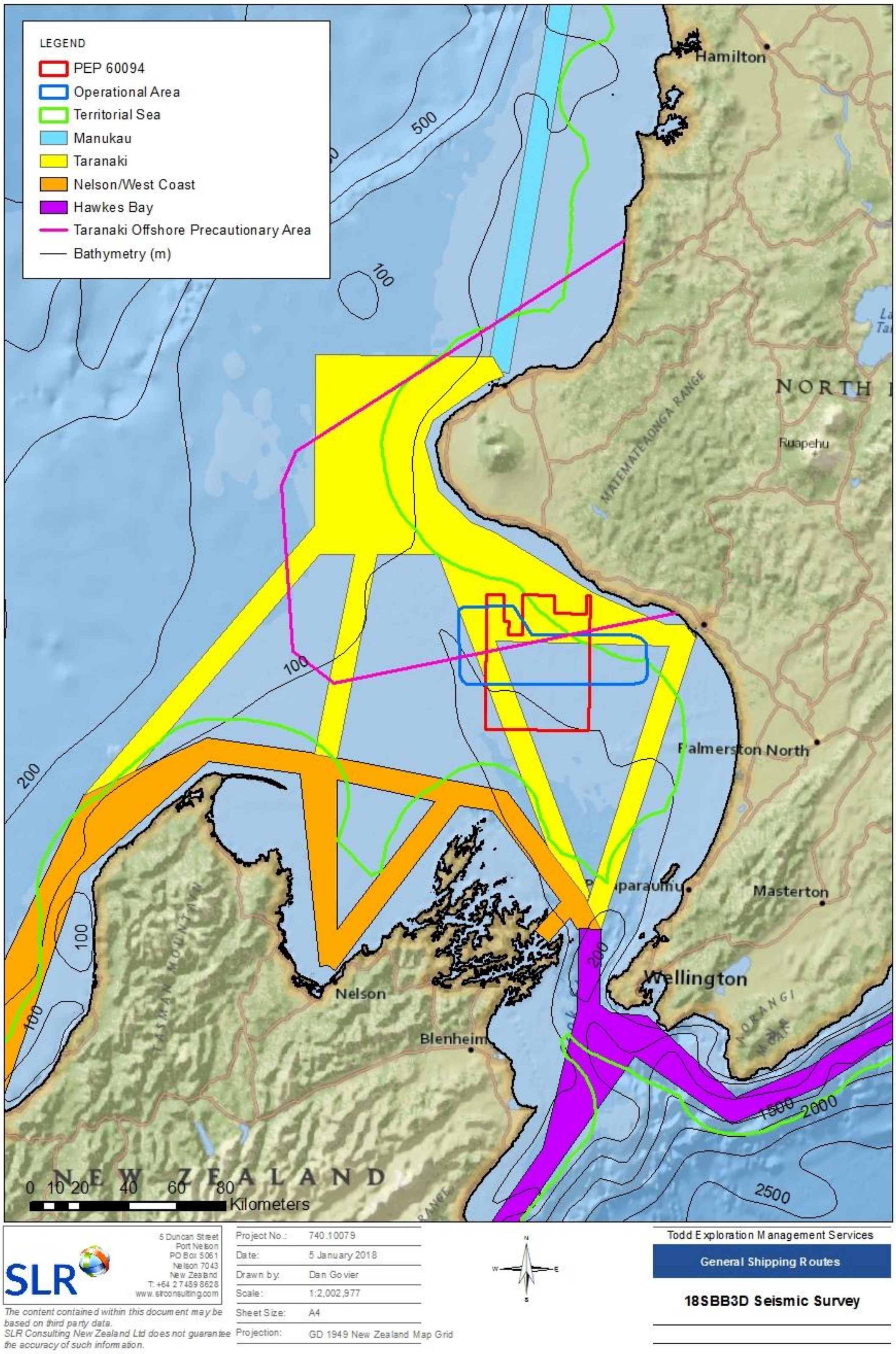
Commercial shipping vessels generally use the most direct path when travelling between ports. There are no dedicated shipping lanes between any New Zealand ports; vessels typically take the shortest possible route. The general shipping routes in the vicinity of the Operational Area are shown in **Figure 23**.

The New Zealand Nautical Almanac provides guidance for vessels operating in the vicinity of production platforms and exploration rigs. The guidance recommends that an adequate safe margin of distance should be maintained, and where there is sufficient sea room, vessels should keep at least 5 M clear of the installation.

A Precautionary Area was established in offshore Taranaki (**Figure 23**) by the International Maritime Organisation in 2007. On account of oil and gas activities, all ships traversing this area must navigate with particular caution in order to reduce the risk of a maritime casualty and marine pollution.

This Precautionary Area is a standing notice in the annual Notice to Mariners that is issued each year in the New Zealand Nautical Almanac. The Almanac lists the navigation hazards within this precautionary area, including the Pohokura, Māui, Maari, Tui and Kupe production fields (see **Section 5.6.4**). During the 18SBB3D seismic survey, the presence of the support and chase vessels will assist with navigation through the Precautionary Area. The *MV Amazon Warrior* and the towed streamer array will also be equipped with AIS systems to assist with safe passage around navigational hazards.

Figure 23 General Shipping Routes Surrounding the Operational Area



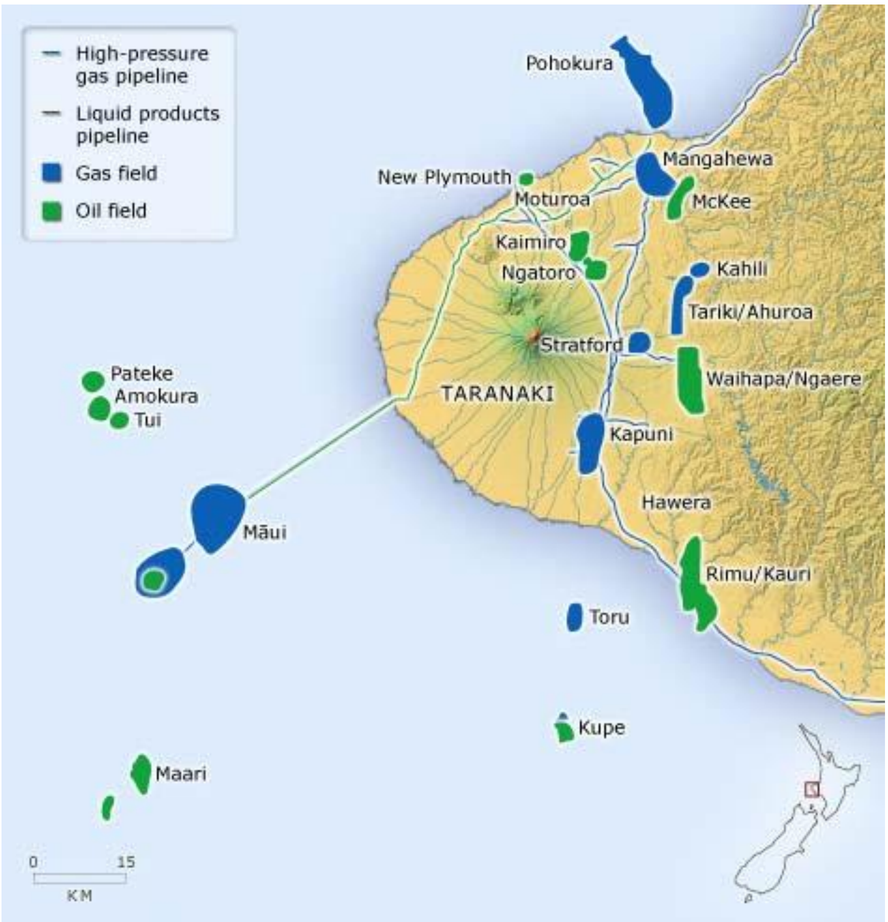
5.6.4 Oil & Gas Activities

Hydrocarbon exploration and production activities in Taranaki have been ongoing for the last 100 years and offshore for more than 50 years. Producing offshore fields include: Maari, Māui, Kupe, Pohokura, and Tui (**Figure 24**). The use of seismic surveys for exploration has been commonplace off the Taranaki coastline since the 1950s. To date, there have been no recorded incidents of harm to marine mammals as a result of seismic operations in the Taranaki Basin.

The Kupe Gas and Light Oil/Condensate Field is the only offshore field in close proximity to the Operational Area; the Maari, Māui and Tui Fields lie in more offshore waters to the west of the Operational Area, while the Pohokura Gas Field is located in northern Taranaki.

The Kupe Gas and Light Oil/Condensate Field lies partially within the Operational Area. This field was discovered in the mid-1980s; however, at this time it was considered to be sub-commercial. Interest in Kupe picked up again in the early-2000's following a change in New Zealand's gas market and decline in production at the Māui Field. Production at Kupe began in December 2009, with permanent production declared on 22 March 2010. Products produced from Kupe are transported to the onshore production station near Hawera, where raw gas is processed to meet specifications for New Zealand's LPG market (NZOG, 2017). The Kupe Platform and associated pipelines are protected by the Submarine Cables and Pipelines Protection (Kupe Gas Project) Order 2008 and lie outside the Operational Area. The Kupe Field is operated by Beach Energy with Genesis and New Zealand Oil and Gas joint venture partners (Oil & Gas Journal, 2017).

Figure 24 Oil and Gas Fields in the Taranaki Basin



Source: http://www.teara.govt.nz/en/map/8934/taranaki-oil-and-gas-fields-2006

6 POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION MEASURES

This section presents an overview of the potential environmental effects which may arise from the operation of the 18SBB3D seismic survey. Effects could potentially occur either under normal operating situations (planned activities) or during an accidental incident (unplanned event). Proposed mitigation measures are also provided throughout this section.

6.1 Environmental Risk Assessment Methodology

An Environmental Risk Assessment (ERA) has been undertaken to identify the significance of each potential effect. The predicted effect is based on the assumption that proposed mitigation measures to avoid remedy or mitigate environmental effects are in place. Hence, risk determination is made for any residual effect that may still occur despite the use of mitigation measures.

The main steps used in the ERA process are:

- 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 23**.The ERA results are described in detail through the remainder of this section.

Table 23: Assessing 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 $\mu Pa^2.s$; 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 $\mu Pa^2.s$; 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 $\mu Pa^2.s$; i.e. Permanent Threshold Shift or other physiological damage is possible.

6.2 Planned Activities

6.2.1 Physical presence of seismic vessel and towed equipment

As outlined in the following sections, a number of potential effects could arise from the physical presence of the seismic vessel, the support vessel and the large span of towed acoustic equipment.

Note: this section does not consider any benthic effects or effects on benthic infrastructure or artefacts as there is no intention (during planned activities) for any equipment to make contact with the seafloor. The effects associated with equipment accidentally making contact with the seafloor are discussed in ***Section 6.3.2****.*

6.2.1.1 Potential effects on marine mammals

Disruption of normal behaviour and displacement of individuals from habitat

Marine mammals in the presence of vessels show two main stereotypical behaviours; avoidance or attraction (Wursig et al., 1998). Both can affect energy expenditure as with either of these responses animals are distracted from engaging in natural behaviours (e.g. feeding, resting, socialising etc.). Avoidance responses are more frequently documented than attraction responses, where avoidance most commonly leads to animals becoming temporarily displaced from an area (Wursig et al., 1998). Displacement from an area is of particular concern when these changes occur frequently over a prolonged period and/or when they affect critical behaviours (i.e. feeding, breeding and resting). Although there is potential for the physical presence of the survey vessels and towed equipment to cause some changes in marine mammal behaviours, such disturbance is predicted to be temporary and localised during short-term seismic surveys.

Ship strikes - collision between a marine mammal and vessel

Entanglement risks associated with towed equipment

Although marine mammals could potentially interact with and become entangled in the towed seismic equipment, it is considered that such interactions would be highly unlikely on account of marine mammals displaying exceptional abilities to detect and avoid obstacles in the water column. In addition, seismic surveys do not involve any loose surface lines, which are known to pose the greatest risk to marine mammal entanglement (Rowe, 2007). Marine mammals routinely interact with fishing gear; however, unlike fishing gear, there is no food attractant involved (i.e. bait or catch) with seismic surveys which might encourage marine mammal presence around the equipment. To SLR's knowledge, there has never been a reported case of a marine mammal becoming entangled in seismic equipment.

Management actions and mitigations:

In accordance with the Code of Conduct, MMOs will be on-watch during daylight hours for all periods of acquisition during the 18SBB3D seismic survey. In addition to this, at least one MMO will be stationed on the bridge during good weather while the seismic vessel is in transit to and from the Operational Area in order to maximise the marine mammal data collected during the survey. The Marine Mammal Mitigation Plan (MMMP) outlines the protocol that MMOs will follow (see **Appendix C**). In addition, MMOs will be vigilant for marine mammal entanglements, will be expected to report any dead marine mammals observed at sea, and will notify DOC immediately should any live sightings of Hector's/Maui's dolphins be made throughout the Operational Area. MMOs will provide weekly reports to DOC (to both the National Office and Taranaki office) and the Environmental Protection Authority.

In summary, it is considered that the risk to marine mammals arising from the physical presence of the seismic vessel, support vessel, and the towed equipment during the short 18SBB3D seismic survey is **medium**.

6.2.1.2 Potential Effects on Seabirds

Seabird interactions with all vessel types are relatively common in both coastal and open waters. Although most interactions are harmless or even positive (e.g. the provision of perching opportunities), some can be detrimental and may even cause injury or death (for instance bird strike and/or entanglement with vessel structures). The detrimental impacts associated with these interactions are typically amplified at night, as seabirds can become disorientated as a result of artificial lighting which increases the risk of seabird collisions (Black, 2005). This is particularly the case for fledglings and novice flyers in coastal locations (Telfer et al., 1987).

Few systematic observations of seabirds around seismic operations have been made. The only study that has attempted to quantify behavioural impacts investigated shorebirds and waterfowl in the Wadden Sea (an intertidal zone of the North Sea) during a seismic survey (Webb & Kempf, 1998). This study concluded that seismic operations had no significant effect on bird counts and distribution; however some evidence of temporary avoidance within a 1 km radius of the seismic vessel was noted.

Management actions and mitigations:

Seismic vessels confer no greater collision threat than any other commercial vessel operating on a 24 hour basis (e.g. fishing vessels). For this reason, no specific mitigation measures are in place to reduce the likelihood of a collision between seabirds and the survey vessels during the 18SBB3D seismic survey. Furthermore, the slow operational speed (4.5 knots) of the seismic vessel possibly serves to reduce the risk of detrimental interactions; and could instead provide a welcome resting place for offshore seabirds. The short-term duration of the survey also serves to restrict the timescale over which any interaction (both positive and negative) could occur.

In summary, the risk to seabirds from the physical presence of the seismic vessel, support vessel and the towed equipment is considered to be.

6.2.1.3 Potential Effects on Other Marine Users

Because of the large span of towed equipment associated with seismic operations, surveys can create a collision hazard and displace other marine users from the Operational Area. In Taranaki waters, these potential impacts are most likely to affect commercial fishing and shipping activities; whereby both may be required to change course to avoid the seismic survey operations. Seismic data acquisition could also cause displacement of fish stocks as discussed in **Section 6.2.2.3.4**.

Management actions and mitigations:

Any collision risks and displacement effects associated with the 18SBB3D seismic survey will be strictly temporary on account of the short term nature (i.e. ~ five days) of seismic operations. In order to manage these potential effects, commercial users have been advised of the proposed operations and will be kept informed with regard to commencement dates and survey progress. In addition, the following measures will be taken to further minimise any effects or risks:

1. Seismic operations will occur 24 hours a day for every day of the survey (weather and marine mammal encounters permitting) to minimise the overall duration of the survey;
2. The survey vessels will comply with the COLREGS (e.g. radio contact, day shapes, navigation lights, etc);
3. The seismic operator will notify other commercial users of the proposed survey;
4. A support vessel will be present to inform other marine users of the approaching seismic vessel;

5. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast on marine radio; and
6. A tail buoy with lights and radar reflector will be displayed at the end of each streamer to mark the overall extent of the towed equipment.

With the above mitigation measures or management practices in place, the environmental risk to any fishing vessels or other marine traffic is considered to be.

6.2.2 Acoustic Disturbance to the Marine Environment

Fundamental to seismic surveying is the introduction of acoustic disturbance (noise) into the marine environment. Although acoustic arrays are designed to direct their sound energy vertically downwards, there is always some residual energy which dissipates laterally into the surrounding water column. The sound energy used during seismic surveys is of low frequency (0.001 – 0.3 kHz) and spreads quickly in water (Richardson et al., 1995). When assessing how far sound spreads laterally in water, one needs to understand the propagation conditions. Where in good propagation conditions, noise will travel further and background noise levels may not be reached for >100 km, while in poor propagation conditions, background levels can be reached within a few tens of kilometres (McCauley, 1994). Propagation conditions are primarily influenced by water temperature, salinity and pressure (DOSITS, 2017a). The acoustic pulse from the seismic source creates a high-intensity pressure wave with an outward flow of energy in the form of water movement. The environmental effect on an animal in the vicinity of a seismic survey is defined by each individual’s interaction with these pressure waves.

The effects of seismic surveys on marine organisms vary depending on the acoustic source (e.g. the source energy, the sound frequency and the exposure duration) and the exposed animal (e.g. species, gender, reproductive status, health and age). The main effects that potentially arise from seismic surveys, as summarised by DOC (2013), are listed below:

- Physiological effects, e.g. trauma and auditory damage;
- Behavioural effects, e.g. avoidance and attraction;
- Perceptual effects e.g. auditory masking; and
- Indirect effects e.g. reduction in prey species.

DOC developed the Code of Conduct as a tool to specifically minimise these potential effects; therefore complying with the Code of Conduct is the primary way in which the potential acoustic effects from the 18SBB3D seismic survey will be managed.

The potential acoustic exposure of marine fauna during the 18SBB3D seismic survey was assessed by STLM. STLM uses input parameters based on the acoustic source array, water column parameters, seabed geology and bathymetry data of the Operational Area. This modelling is required by the Code of Conduct for surveys that will occur within an Area of Ecological Importance. The results of the STLM are presented below.

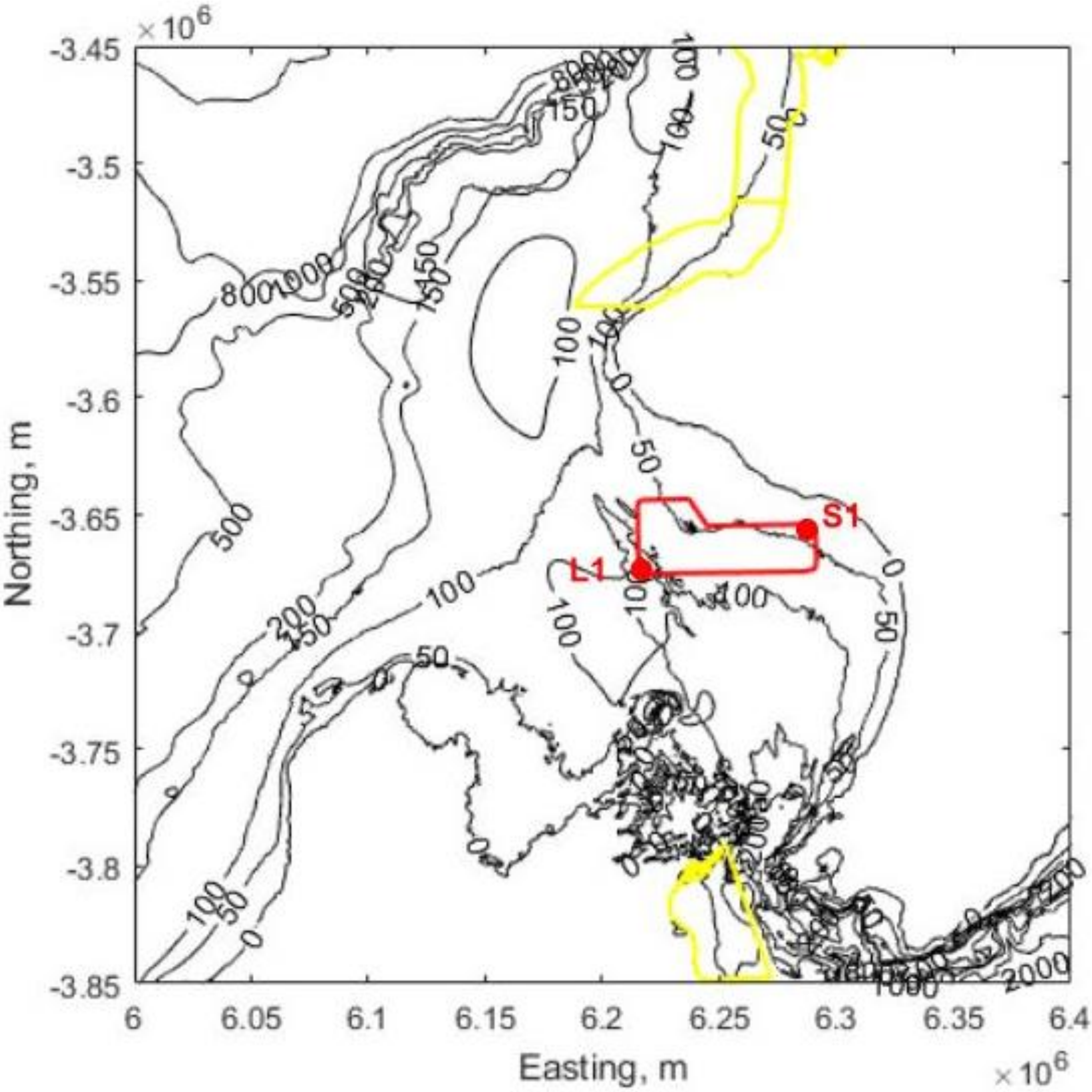
6.2.2.1 Sound Transmission Loss Modelling

STLM was undertaken to predict the received SELs expected from the 18SBB3D seismic survey in order to assess for compliance with the mitigation zones outlined in the Code of Conduct and to predict sound propagation into sensitive areas. This is done through short range and long range modelling respectively. The modelling methodology addresses the horizontal and vertical directionality of the acoustic array while taking into consideration the water depths and substrate types of the Operational Area. The complete modelling report is provided as **Appendix A**.

When selecting model inputs, a number of variables were assessed including water depth, proximity to sensitive sites (i.e. the West Coast North Island Marine Mammal Sanctuary), seasonal sound speed profiles through the water column, and substrate type (e.g. clay, sand, shelly sediment, etc.). Based on these variables, worst case conditions and modelling locations were selected to predict the highest SELs possible during the 18SBB3D seismic survey. The worst cases for short range and long range modelling are as follows:

- A single location, S1 (**Figure 25**) was selected for the short range modelling. This location represented the shallowest water depth within the Operational Area (30 m);
- A second location, L1 (**Figure 25**) was selected for the long range modelling. This location was was selected as it has relatively deep water depth (101 m) which favours long range sound propagation, particularly towards the further offshore regions;
- A summer seasonal sound speed profile was selected for both modelling scenarios, based on the timing of the survey and the high propagation of sound during this season; and
- A fine sand substrate was selected as this substrate type is the most reflective substrate present in the Operational Area.

Figure 25 Sound Modelling Locations for the Operational Area



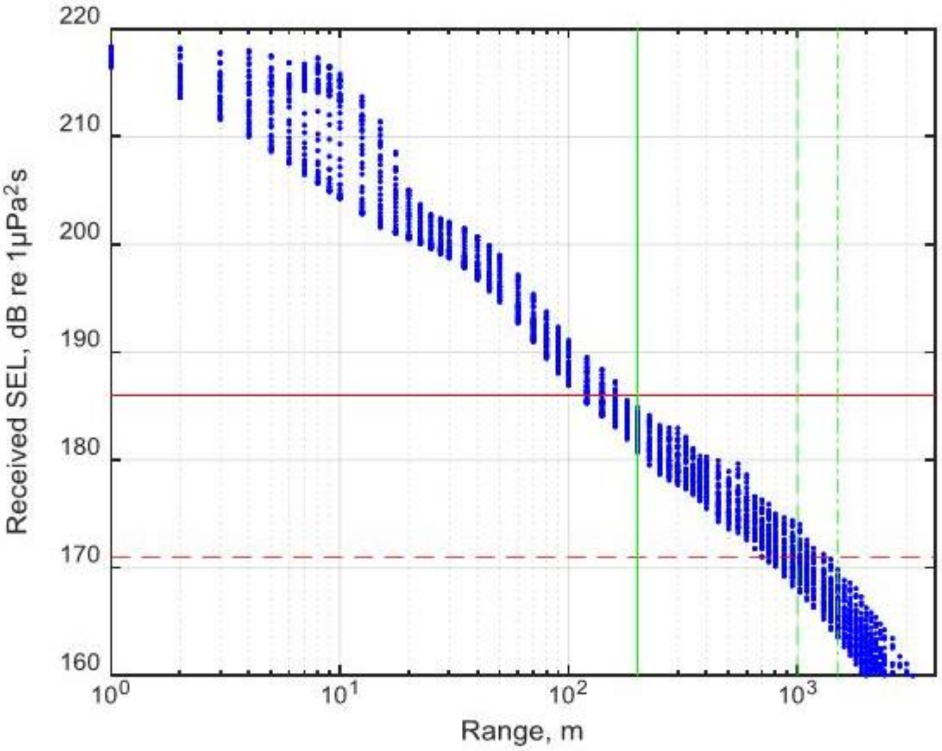
Short range modelling results

Short range modelling allows for predictions to be made about the likelihood of compliance with the standard mitigation zones in the Code of Conduct. The modelled results are illustrated in **Figure 26** and **Table 24**; these results predict that the maximum SELs were:

- 185 dB re 1 µPa²-s at 200 m. In compliance with the Code of Conduct, this level is less than 186 dB re 1 µPa²-s at a distance of 200 m; hence marine mammals beyond 200 m from the source will not be subject to PTS;
- 174.2 dB re 1 µPa²-s at 1,000 m. To be compliant with the Code of Conduct this level needs to be less than 171 dB re 1 µPa²-s at a distance of 1,000 m. The modelling predicts that this level will be exceeded during the 18SBB3D seismic survey; hence the standard mitigation zone of 1.000 m for Species of Concern without calves does not offer sufficient protection from TTS); and
- 169.8 re 1 µPa²-s at 1,500 m. In compliance with the Code of Conduct, this level is less than 171 dB re 1 µPa²-s at a distance of 1,500 m. Hence Species of Concern with calves will not be subject to TTS).

These results indicate that the standard mitigation zones of 200 and 1,500 m (as stipulated in the Code of Conduct) are appropriate for use during the 18SBB3D seismic survey. However, maximum received SELs are above 171 dB re 1μPa²·s at 1.0 km from the source indicating that the 1 km mitigation zone does not sufficiently protect marine mammals from TTS. On the basis of these results TEMS will solely use the larger 1.5 km mitigation zone throughout the 18SBB3D survey for all Species of Concern, regardless if they are accompanied by calves or not.

Figure 26 Maximum Received SELs from the Acoustic Source at Location S1



Red lines show mitigation thresholds of 186 dB re 1μPa²·S (solid) and 171 dB re 1μPa²·S (dash). Green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Table 24 Ranges from the source array where the SEL thresholds are predicted to occur

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
S1	30	Fine sand	170 m	1,350 m

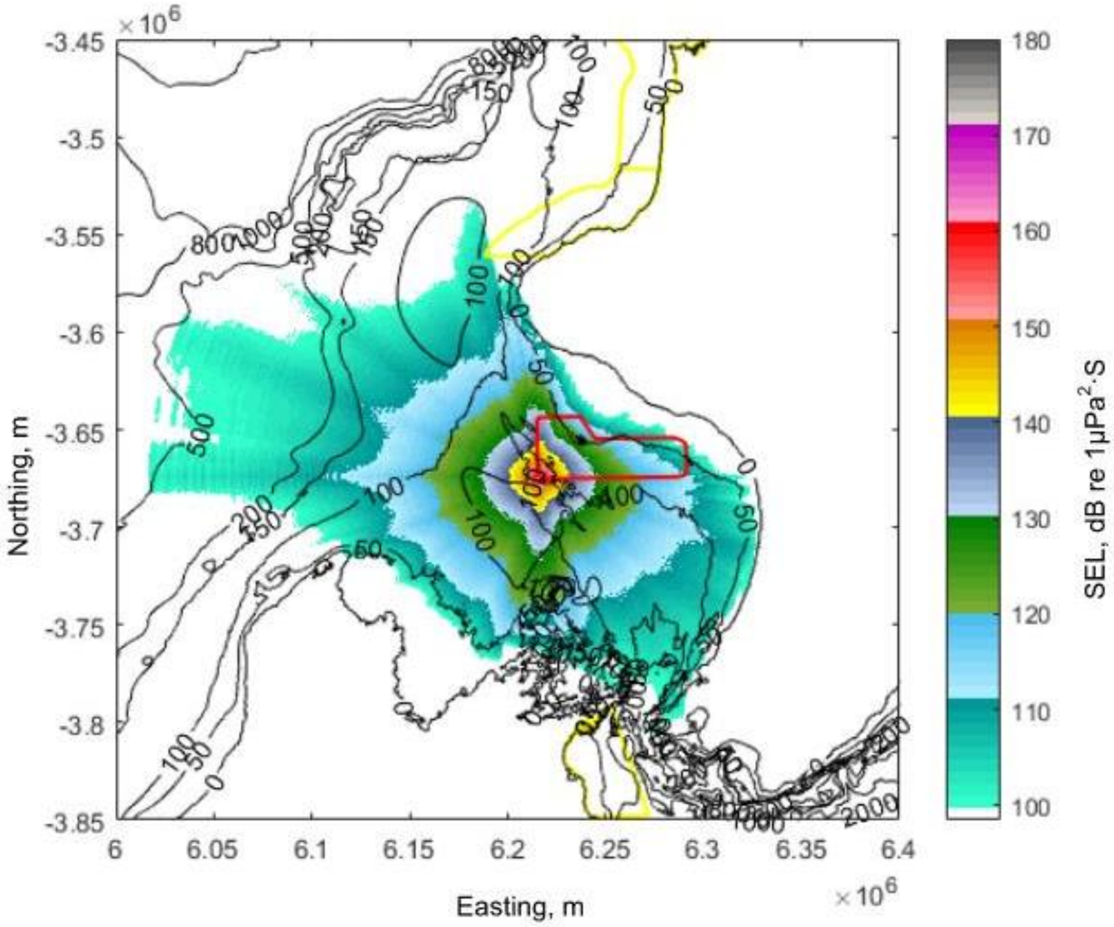
Long range modelling

Long range modelling predicts the received SELs over a range of tens to hundreds of kilometres from the array source location and has been used to assess the noise impact from the survey on the South Taranaki Bight where blue whales are commonly observed. Received SELs at far-field locations vary significantly with angle and distance from the source (**Figure 27**) due to a combination of the directivity of the source array, and propagation effects caused by bathymetry, seabed reflectivity and variations in the sound speed profile. Sound travelling 'up-slope' (from deep to shallow water) attenuates rapidly as can be seen in an easterly direction; whereas sound traveling down-slope propagates extensively.

The maximum SELs received along the South Taranaki Bight coast are predicted to be below 100 dB re 1μPa²·s due to its shallow and up-slope bathymetric features. North of Farewell Spit, the maximum

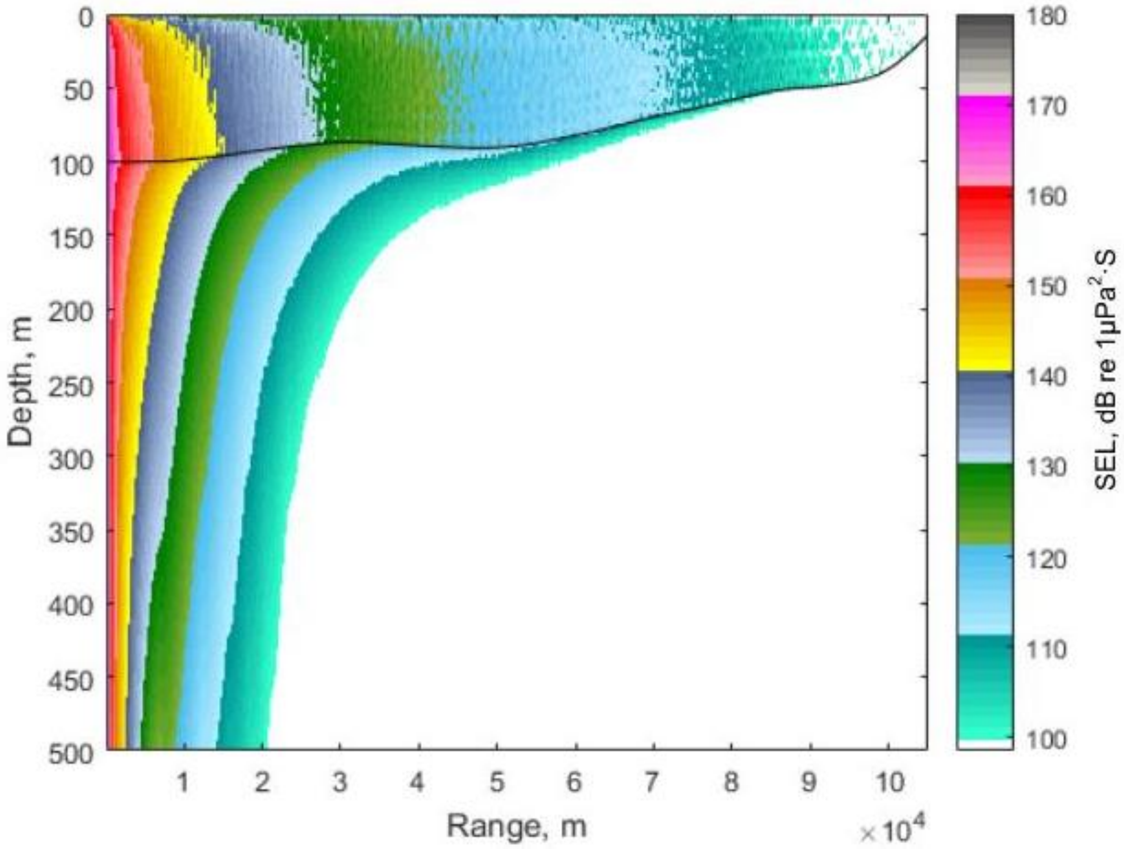
SELs are predicted to be 100 - 110 dB re 1µPa²·s within the nearshore region (water depths 10 m - 50 m). The maximum SELs are predicted to be below 100 dB re 1µPa2·s at both the West Coast North Island Marine Mammal Sanctuary in the north and the Clifford and the Cloudy Bay Marine Mammal Sanctuaries in the south.

Figure 27 Modelled Maximum SELs to a Range of 200 km



The long-range modelling is also able to provide an estimate of the SELs at the seafloor, where directly below the acoustic source in a water depth of 100 m, SELs no greater than approximately 165 dB re 1µPa²·s are predicted (Figure 28).

Figure 28 Modelled SELs with Range and Water Depth in the in-line Direction



Note: the black line in this figure represents the seafloor profile from west to east.

6.2.2.2 Potential Physiological Effects

The Code of Conduct recognises that physiological effects may be associated with intense underwater noise, where trauma to body tissues and auditory damage are noted as being the main impacts (DOC, 2013). Physiological impacts however are not limited to marine mammals.

6.2.2.2.1 Marine Mammals

In the event that a marine mammal is exposed to high intensity underwater noise at close range, physiological effects such as trauma or auditory damage may result (DOC, 2013). Because of inter-specific differences it is difficult to know at exactly what sound intensity these physiological effects occur, although traumatic thresholds have been developed based on a few experimental species (Richardson et al., 1995; Gordon et al., 2003).

Threshold shift, or hearing loss, is the main type of auditory damage documented in marine mammals. Threshold shifts occur when exposed animals experience an elevation in the lower limit of their auditory sensitivity. These shifts can be permanent (i.e. Permamnent Threshold Shift, PTS) or temporary (i.e. Temporary Threshold Shift (TTS). TTS is more common in marine mammals due to their mobile, free-ranging nature which allows them to avoid areas in which sound exposure levels would be dangerously high.

The estimated onset of PTS in marine mammals has been calculated by Southall et al. (2007) to be 198 dB re 1 μPa^2-s for all cetaceans exposed to sound pulses and 186 dB re 1 μPa^2-s for pinnipeds in water. In addition, the criteria for TTS-onset in marine mammals were calculated to be 183 dB re 1 μPa^2-s for all cetaceans and 171 dB re 1 μPa^2-s for pinnipeds (Southall et al., 2007).

The observed effects of mid-frequency active sonar on beaked whales is an interesting consideration, as although sonar represents a vastly different sound source to that used during seismic operations, physiological responses (e.g. gas embolisms and changes in blood biochemistry) have been reported for some species of beaked whales following sonar exposure (Fahlman et al., 2014). This perhaps indicates that beaked whales are particularly sensitive to anthropogenic noise (Stimpert et al., 2014).

Management actions and mitigations:

For seismic surveys in New Zealand's marine waters, the Code of Conduct uses information from Southall et al. (2007) to set thresholds that predict at what sound intensity physiological effects could occur. The Code of Conduct has taken a conservative approach to predict both temporary and permanent physiological impacts to marine mammals as follows:

- 186 dB re 1 μPa^2-s; i.e. the lowest SEL at which PTS is possible
- 171 dB re 1 μPa^2-s; i.e. the lowest SEL at which TTS is possible

The Code of Conduct requires that seismic operators comply with a suite of mitigation measures to minimise the risk of threshold shifts (both permanent and temporary) to marine mammals.

STLM results (see **Section 6.2.2.1**) indicate that the standard mitigation zones of 200 and 1,500 m (as stipulated in the Code of Conduct) are appropriate for use during the 18SBB3D seismic survey. However, maximum received SELs are above 171 dB re 1$\mu Pa^2 \cdot$s at 1.0 km from the source indicating that the 1 km mitigation zone does not sufficiently protect marine mammals from TTS. On the basis of these results TEMS will solely use the larger 1.5 km mitigation zone throughout the 18SBB3D survey for all Species of Concern, regardless if they are accompanied by calves or not. Compliance with the mitigation measures outlined in the Code of Conduct (i.e. pre-start observations, soft starts and shut-down procedures) serves to reduce the risk of threshold shifts during the proposed survey. The typical avoidance behaviour exhibited by marine mammals (see **Section 6.2.2.3.1**) also assists with minimising the risk to marine mammals to as low as reasonably practicable.

As per the Code of Conduct requirements, ground-truthing will be undertaken during the survey to verify the results of the STLM. In order to do this, representative data recorded on the seismic streamers during the seismic survey will be used to compare actual sound exposure levels with STLM predictions and to measure the SELs at each mitigation zone boundary.

In the event that any stranding mortality occurs during the 18SBB3D seismic survey or shortly after the cessation of seismic operations, TEMS will, on a case-by-case basis and in consultation with DOC, support the necropsy of any fresh dead cetaceans in an attempt to determine the cause of death and to check for any physiological damage to auditory organs. DOC will be responsible for all logistical aspects associated with the necropsy, including coordination with pathologists at Massey University to undertake the work.

From the information above it is considered that the acoustic effects could put at risk of physiological effects.

6.2.2.2.2 Seabirds

There is a notable paucity of information regarding the potential effects of seismic surveys on seabirds. As high intensity acoustic disturbance clearly has the potential to cause physiological damage to other taxa (e.g. marine mammals and fish); it is therefore reasonable to assume that seabirds could also suffer physiological effects if they were to dive in close proximity to an active acoustic source. The likelihood of birds diving in the immediate vicinity of the acoustic source is limited on account of the fact that seabirds resting on the sea surface are typically startled by an approaching seismic vessel and therefore would be displaced from the immediate line of transit well ahead of the acoustic source (MacDuff-Duncan & Davies, 1995). Those birds remaining on the sea surface are unlikely to suffer physiological effects as the Lloyd Mirror effect means that noise levels at the sea surface are lower than those deeper in the water column (Carey, 2009). Another consideration is that the small bait fish that form the primary target of many seabird species are likely to be displaced from the immediate vicinity of the acoustic source (see **Section 6.2.2.3.4**). Hence, seabirds are expected to detect this change in fish distribution and cease any foraging dives in the area around the acoustic source from which fish have been displaced.

<u>Management actions and mitigations:</u>

No specific mitigation measures are in place to reduce the potential effects of seismic surveys on seabirds. However, the short-term duration of the survey serves to restrict the timescale over which any effect could occur.

On account of the above, it is considered that the risk of physiological effects to seabirds during the 18SBB3D seismic survey is.

6.2.2.2.3 Marine Reptiles

In comparison to marine mammals, little attention has been placed on the potential effects of seismic surveys on sea turtles (Nelms et al., 2016) and no information is available for sea snakes. Despite the ear of sea turtles being adapted to detect sound in water, no studies have yet investigated hearing loss or damage to sensory hairs caused by underwater noise (Popper et al., 2014). Hence no information is available on threshold shifts in sea turtles. Ketten et al. (2005) concluded that fresh sea turtle cadavers showed a high level of resilience to explosives, and this information was cited by Popper et al. (2014) as evidence that they may too be resistant to damage from seismic sources. A proposed cumulative SEL at which mortality or potential mortal injury has been suggested by Popper et al. (2014) to occur at 210 dB.

<u>Management actions and mitigations:</u>

No specific mitigation measures are in place to reduce the potential effects of seismic surveys on marine reptiles. Both sea turtles and sea snakes are unlikely to be present during the 18SBB3D seismic survey, therefore the risk of physiological effects from underwater noise is considered to be.

6.2.2.2.4 Fish

A number of physiological effects associated with exposure to underwater noise have been reported for fish. These effects, which appear to be dependent on species and sound intensity, include an increase in stress levels (Santulli et al., 1999; Smith, 2004; Buscaino et al., 2010), temporary or permanent threshold shifts (Smith, 2004; Popper et al., 2005), or damage to the animal's sensory organs (McCauley et al., 2003).

Hearing threshold shifts have been widely documented for fish species internationally. For example, Popper et al. (2005) studied northern pike, broad whitefish, and lake-chub to test for physiological damage following exposure to a small seismic source (730 in^3) with a received mean SEL of 176-180 dB re 1µPa^2-s. This study documented no threshold shift for broad whitefish, but both northern pike and lake chub exhibited temporary threshold shifts whereby they showed a 10 - 25 dB hearing loss that recovered within 24 hours after exposure. This study highlights that the response of one species may be quite different to another. It should also be noted that pelagic fish will typically move away from a loud acoustic source (see **Section 6.2.2.2.4**), minimising their exposure to underwater noise and any associated potential for hearing damage.

Few studies have investigated the effects of underwater noise on any of New Zealand's marine fish species. Instead, international studies are typically relied upon as an indication of the type of physiological effects that have been documented elsewhere. An exception to this, is a study by McCauley et al. (2003) who looked at the effects of seismic source exposure on snapper (*Pagrus auratus*) which is a species found in New Zealand waters. This controlled exposure experiment simulated a seismic vessel approaching then moving away, during which caged fish were exposed to SELs that exceeded 180 dB re 1µPa^2-s. After the experiment, the fish were sacrificed so that their ear structures could be examined for any damage. The findings of this study showed that a small number (2.7%) of the total number of sensory hair cells sustained severe damage in several of the exposed fish even two months after exposure. While this result could represent permanent auditory damage, the authors are quick to point out that the caged fish had no ability to escape the sound field; hence could have been exposed to SELs much greater than those of wild fish in the vicinity of a survey vessel.

The effects of seismic surveys on reef fish in Western Australia were investigated during a comprehensive study by Woodside Energy during commercial seismic surveys between 2008 and 2010 (Battershill, 2016). This study was the first ever in situ experiment to assess the effects of seismic surveys on fish and coral in real-time during a commercial survey. Water depths within the study area ranged from 20 – 1,100 m and the seismic source had a total capacity of 2,005 in^3. Sound loggers and remote underwater video was deployed and fish exposure cages were utilised to contain captive reef fish. The key finding of this study was that no auditory damage was documented for any fish species during this study and overall impacts on coral communities were deemed to be minimal. Despite this study occurring in tropical reef communities, its relevance is of global significance as it provides evidence to reject the hypothesis that site-attached reef fish in shallow waters are most likely to sustain effects from seismic surveys (on the basis that these species have a restricted ability to escape the sound field). It therefore follows that pelagic fish should be even less likely to be affected by seismic surveys as they can readily leave the areas of greatest sound exposure levels.

Popper et al. (2014) developed guidelines to predict at what threshold levels seismic surveys might cause physiological damage to fish. These thresholds are presented in **Table 25**.

.

Table 25 Thresholds for Physiological Injury from Acoustic Disturbance for Fish

	Mortality and potential mortal injury	Recoverable injury	Temporary Threshold Shift
Fish with no swim bladder	>219 dB SEL_{cum} or >213 dB peak	>216 dB SEL_{cum} or >213 dB peak	>> 186 dB SEL_{cum}
Fish with swim bladder that is not involved with hearing	210 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	>> 186 dB SEL_{cum}
Fish with swim bladder that is involved with hearing	207 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	186 dB SEL_{cum}

Source: Popper et al. (2014)

Management actions and mitigations:

During the 18SBB3D seismic survey there is potential for the acoustic source to induce physiological effects on fish species that are in close proximity to the acoustic source; however, the risk of any lasting physiological effects are considered to be **minor** as 1) most pelagic fish are predicted to move away from the acoustic source to avoid the greatest SELs; 2) soft starts will allow pelagic fish to leave the vicinity before full operational capacity is reached and 3) STLM indicates that injury thresholds (according to Popper et al., 2014) will only be exceeded in the immediate vicinity of the acoustic source (within approximately 10 m).

6.2.2.2.5 Cephalopods

Controlled exposure experiments have been undertaken on captive cephalopods to determine possible physiological effects of underwater noise. Andre et al. (2011) exposed four cephalopod species to low frequency sounds with SELs up to 175 dB re 1µPa^2-s. All of the exposed animals exhibited similar changes to the sensory hair cells of the statocysts that are responsible for the animal's sense of balance. This damage gradually became more pronounced in animals that were continuously exposed to the noise source for up to 96 hours. Andre et al. (2011) estimated that such trauma effects could occur out to 1.5 – 2 km from an operating acoustic source. Respiration rates of *Octopus ocellatus* were suppressed during periods of exposure to low frequency sound (Kaifu et al., 2007).

Squid form pelagic schools over the continental shelf in waters up to 500 m deep, but are most prevalent in water depths less than 300 m (MPI, 2015). New Zealand squid species are short-lived, fast growing, and have high fecundity rates (MPI, 2015). There is the potential for schools of squid to be exposed to acoustic disturbance during the 18SBB3D seismic survey; however, their pelagic life style means that squid can readily move away from the highest sound exposure levels to avoid physiological damage. In addition, their life history traits mean that populations are well adapted to cope with episodes of disturbance or decreased survival rates. On this basis, we anticipate no long-term effects to squid populations during the proposed survey. Octopuses on the other hand are typically solitary and demersal. Therefore, it is possible that individual octopuses will be subject to acoustic exposure during the SouthTaranaki 3D Seismic Survey; however being solitary, only occasional individuals are likely to be affected.

Management actions and mitigations:

No specific mitigation measures are in place to reduce the potential effects of seismic surveys on cephalopods; and based on the information above the risk of physiological trauma to cephalopod species is considered to be.

6.2.2.2.6 Benthic Invertebrates

Published literature on the effects of underwater noise on crustaceans, shellfish and deepwater benthic invertebrates (i.e. corals) is summarised below. Research has shown that macroinvertebrates (e.g. scallops, sea urchins, mussels, periwinkles, crustaceans, shrimp, and gastropods) suffer very little mortality below sound levels of 220 dB re 1µPa@1m, while some show no mortality at 230 dB re 1µPa@1m (Royal Society of Canada, 2004). However, Carroll et al. (2017), noted that limited investigations on the physiological responses of marine invertebrates to seismic noise are available.

Crustaceans

Studies in the 1990s indicted that crustaceans were relatively tolerant to acoustic disturbance (Royal Society of Canada, 2004) on account of their lack of a swim bladder (Moriyasu et al., 2004). However, recent physiological studies are challenging this train of thought and relevant research findings are listed below:

- Amphipods were exposed to a seismic source with a source level of 223 dB re 1µPa at distances of 0.5 m or greater with no physiological effects detected (Kosheleva, 1992; Dalen, 1994 as reported in Moriyasu et al., 2004);
- No mortality or evidence of reduced catch rate was noted 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 as reported in Moriyasu et al., 2004);
- Christian et al. (2004) conducted a stress test on snow crabs to investigate the impacts of seismic surveys and found no stress bio-indicators present following seismic exposure;
- Solan et al. (2016) documented no change in tissue levels of glucose or lactate in lobsters exposed to impulsive noise;
- The effect of seismic surveys on American lobsters (*Homarus americanus*) was assessed and although there was no reported mortality of mechanosensory damage even at very high sound levels (227 dB peak-to-peak), serum biochemistry changes were documented weeks to months after exposure, indicating the potential for sub-lethal organ stress (Payne et al., 2007); and
- Day et al. (2016) exposed red rock lobster (*Jasus edwardsii*) to a 150 in^3 acoustic source in field studies off Australia. Key findings of this study were that 1) statocyst hair cells of exposed individuals sustained long-term damage following seismic exposure; however, these lobsters did not show impaired righting reflexes suggesting that affected individuals had adapted to cope with this damage; and 2) haemolymph biochemistry showed no response to seismic exposure, indicating that lobsters were physiologically resilient to acoustic disturbance; however, haemolymph counts were slightly lower in exposed lobsters than in control lobsters and the relevance of this lowered haemolymph count is unknown.

Shellfish

The potential for physiological damage of shellfish varies with the species exposed and the exposure circumstances (e.g. source level and duration, etc.). Relevant research findings are listed below:

- Harrington et al. (2010) documented no changes to scallop meat and roe quality after two different seismic surveys, and blue mussels (*Mytilus edulis*) exposed to a seismic source level of 223 dB re 1µPa at distances of 0.5 m or greater showed no physiological effects (Kosheleva, 1992; Dalen, 1994 as reported in Moriyasu et al., 2004);
- Solan et al. (2016) documented no change in tissue levels of glucose or lactate in clams exposed to impulsive noise, but La Bella et al. (1996) described how the levels of glucose, hydrocortisone and lactate increased in clam tissues after seismic exposure; and

- Shell damage was associated with high intensity seismic source exposure for one of three species of mollusc exposed to a source level of 233 dB re 1 µPa at a distance of 2 m; whereby the Iceland scallop (*Chlamis islandicus*) suffered splits to the shell (Matishov, 1992 as reported in Moriyasu et al., 2004); and
- Exposed scallops (*Pecten fumatus*) had significantly lower haemocyte levels (a proxy for circulation, immunity and stress) in response to seismic exposure (150 in^3) when compared to control scallops. Day et al. (2016) noted that the ecological implications of these changes warrant further investigation, although it seems that exposed scallops could suffer from a depressed immune response.

Management actions and mitigations:

The sound exposure level from a typical seismic array (3,000 in^3) reduces with depth; at the seafloor, the SELs from a 3,000 in^3 array would be lower than 230 dB re 1µPa at a water depth of 30 m; and lower than 220 dB re 1µPa at a water depth of 80 m (Duncan, 2016). Despite the proposed acoustic source for the 18SBB3D seismic survey (5,085 in^3) being substantially larger than the 3,000 in^3 source evaluated by Duncan (2016), the array configuration is such that SELs directly below the 5,085 in^3 acoustic source are not prediected to exceed 180 dB re 1µPa at the seafloor through most of the Operational Area (**Figure 28**).

No specific mitigation measures are in place to reduce the potential effects of seismic surveys on benthic invertebrates; however, based on the information above, the risk of the 18SBB3D seismic survey on benthic invertebrates is considered to be **minor**, with any effects predicted to be highly localised and no population effects anticipated.

6.2.2.2.7 Plankton

Phytoplankton and zooplankton are the primary components of the plankton community; however, it is important to note that the larvae of fish and invertebrates generally have a pelagic planktonic stage during early development; whereby they too are considered to be zooplankton. Until recently mortality of plankton was believed to occur only in the immediate vicinity (i.e. within 5 m) of an active acoustic source (Payne, 2004; DIR, 2007). However, new research by McCauley et al. (2017) has provided evidence to suggest that seismic surveys may cause significant mortality to zooplankton populations.

McCauley et al. (2017) used three techniques to assess the health of the plankton community in relation to exposure to a single 150 in^3 acoustic source. The three techniques used were sonar surveys, net tows for zooplankton abundance, and counts of dead zooplankton. This analysis occurred both before and after seismic exposure. The zooplankton community during the experiment was comprised of copepods (71%), cladocerans (15%), euphausiid larvae (*Nyctiphanes australis*) (4%), appendicularians (5%), and ‘other’ (5%). The key findings of the study are listed below:

- There was a statistically significant lower abundance of zooplankton after exposure, with a median 64% decrease one hour after exposure;
- A 50% reduction in zooplankton abundance was detected within 509 – 658 m of the source. The SEL at this range was 156 dB 1 $\mu Pa^2 s^{-1}$;
- The range at which no impact was detected on zooplankton abundance was 973 - 1,119 m; where the SEL was 153 dB 1 $\mu Pa^2 s^{-1}$;
- There were two to three times more dead zooplankton post exposure;
- There was 100% mortality in krill larvae at all distances sampled post exposure;
- 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;
- Statocyst damage was hypothesised to be the cause of zooplankton mortality; and
- Flow on effects to marine food webs should be considered as an outcome of this study.

The oil and gas industry is concerned by these findings and has commissioned further research into the effects of seismic sound on plankton. In particular the Commonwealth Scientific and Industrial Research Organisation are modelling the potential impacts of a typical marine seismic survey (3,200 in^3 source over an area of 2,900 km^2 for 35 days) based on the McCauley et al. (2017) results. Early modelling results indicate that although zooplankton biomass within the survey area was reduced out to 2.5 km from the source, it recovered within three days after completion of the survey and there appeared to be no discernible regional impacts from the modelled seismic survey (Richardson et al., 2017). Richardson and his colleagues noted that the modelling predicted that zooplankton populations would recover quickly after seismic exposure due to their fast growth rates, and the dispersal and mixing of zooplankton in the offshore marine environment.

While these results are of interest, it is important to put them into context in order to be able to understand how they might relate to the 18SBB3D seismic survey which is proposing to use a 5,085 in^3 acoustic source over a Survey Area which covers approximately 1,856 km^2 for a period of up to five days. Hence, the source size, survey area and survey duration for this survey are significantly greater than what was modelled. Without sophisticated modelling it is impossible to predict how widely plankton in the vicinity of the 18SBB3D seismiic survey will be affected; however it is reasonable to assume that some mortality will occur at a larger distance from the source, over a larger area, and over a greater period of time than what was modelled by Richardson et al (2017).

Data on the potential effects of seismic operations on commercially important planktonic larvae are scarce; however, New Zealand scallop larvae were experimentally exposed to seismic pulses (160 dB re 1 µPa at 1 m at 3 second intervals) in order to assess the effect of noise on early larval development (Aguilar de Soto et al., 2013). The effects of noise exposure at 24 to 90 hours of development were investigated and compared to a control group (which experienced no anthropogenic noise). Of the experimental larvae, 46% showed abnormalities in the form of malformations, such as localised bulges in soft tissues. No malformations were observed within the control group. In contrast to this, Day et al. (2016) assessed the development and hatching rates of red rock lobster larvae following seismic exposure and could not detect any differences between exposed larvae and control larvae. Hence, the effects of seismic on planktonic larvae appear to be highly species specific.

Impacts on zooplankton populations may lead to indirect effects on other components of the marine food web, these effects are discussed in **Section 6.2.2.5.** In particular, the relationship between blue whales and krill provide a primary focus for this discussion.

<u>Management actions and mitigations:</u>

From the information above it is clear that operations may have some detrimental effects on plankton communities. However, no specific mitigation measures are in place to reduce these potential effects The high energy marine environment of the Operational Area is likely to promote fast recovery of plankton populations on account of high levels of dispersal and mixing. It is therefore considered that the population level risk to plankton will be.

6.2.2.3 Potential Behavioural Effects

An animal will elicit a behavioural response as an instinctive survival mechanism that serves to protect it from injury. The most commonly observed behavioural response to active seismic operations is avoidance, which has been widely documented for marine mammals (e.g. Goold, 1996; Stone & Tasker, 2006; Thompson et al., 2013) and fish (e.g. Engas et al., 1996; Slotte et al., 2004), and which can lead to the displacement of animals from optimal habitat. Avoidance and displacement are the most likely behavioural effects expected from the 18SBB3D seismic survey. While short-term displacement is unlikely to have any lasting implications for affected individuals, long-term displacement could lead to animals relocating to sub-optimal or high-risk habitats and could therefore cause negative consequences such as increased exposure to predators or decreased foraging/mating opportunities. The potential behavioural effects for those faunal groups that may elicit them are discussed below.

6.2.2.3.1 Marine mammals

Stone and Tasker (2006) undertook a review of 201 seismic surveys within United Kingdom waters to analyse acoustic effects on cetaceans. This study concluded that most odontocetes (toothed whales) were likely to exhibit a clear lateral avoidance response, while mysticetes (baleen whales) demonstrated a more moderated lateral response. Examples of these patterns are provided below.

Displacement of harbor porpoises was observed by Thompson et al. (2013) when animals were exposed to peak-to-peak sound pressure levels of 165-175 dB re 1 µPa from a 470 in^3 acoustic source over ranges of 5 – 10 km. Displacement was temporary in this study, with pre-exposure distribution resuming within a few hours. During this study a degree of habituation towards the sound source was also observed, with the magnitude of displacement declining throughout the 10 day survey period (Thompson et al., 2013). Based on these observations, the authors concluded that prolonged seismic surveys did not lead to broad-scale displacement of marine mammals. Whilst this study provides a good example of odontocetes displacement, the acoustic source used (470 in^3) is substantially smaller than the source that will be used during the 18SBB3D seismic survey; therefore the zone of influence around a larger acoustic source is expected to be larger.

During a study by Richardson et al. (1995) evidence was found to suggest that migrating bowhead whales avoided an operating seismic source by 20 – 30 km. Subsequent to this Blackwell et al. (2015) documented changes in bowhead whale calling rates to demonstrate that the magnitude of a response was heavily dependent upon the received sound levels, and that this effect was likely to apply to distributional changes as well. In addition to this, migrating humpback whales exposed to 160 – 170 dB re 1 µPa (peak to peak) sounds from seismic surveys consistently changed their course and speed to avoid any close encounters with a seismic vessel (McCauley et al., 2003).

While displacement has been demonstrated in some species and circumstances, a number of studies have recorded no marine mammal distributional change in the vicinity of seismic operations. For instance sperm whales in the Gulf of Mexico were tagged and monitored by Benoit-Bird et al. (2008) in the presence of seismic activity. During this study eight whales were exposed to sound levels between 131 to 164 dB re 1 µPa peak to peak at ranges of 1.4 - 12.6 km from the sound source and no changes in heading or other avoidance behaviours were detected.

The impacts of seismic surveys on beaked whales are largely unknown, but based on their observed responses to mid-frequency active sonar (increased swim speed and unusual dive behaviours) this group is believed to be particularly sensitive to anthropogenic noise (Stimpert et al., 2014). Although sonar represents a vastly different sound source, in the absence of any data on the effects of seismic surveys on beaked whales, their responses to sonar provide a useful indication of what might be expected with regard to other underwater noise sources.

Increased surface behaviours (such as breaching) may also provide a means of acoustic avoidance in the presence of a seismic survey (McCauley et al., 1998; McCauley et al., 2003). These surface behaviours reduce exposure to underwater noise on account of the 'Lloyd mirror effect' (Carey, 2009) which significantly reduces sound intensity in the upper-most part of the water column.

Other stress-related behaviours have also been documented for some species in the vicinity of seismic surveys (or under simulated conditions) including changes in respiration rates (Richardson et al., 1995), changes in swim speed (Stone & Tasker, 2006), changes in diving behaviour (Richardson et al., 1995) and increases in stress hormones (Romano et al., 2004).

In some circumstances marine mammals are attracted to operating seismic vessels, for instance humpback whales approached an operating single acoustic source during a four year study north of Brisbane (Noad et al*.*, 2011); sperm whales were noted to approach closer to active seismic sources than inactive sources, although this difference was not statistically significant (Stone & Tasker, 2006); and New Zealand fur seals are also known to occasionally approach operating seismic vessels (Lalas & McConnell, 2016).

Typically, the distribution of marine mammals is linked to that of their prey (see Fielder et al., 1998), therefore avoidance of the seismic vessel could lead to abandonment of valuable feeding grounds (e.g. large aggregations of krill or fish) or reduced foraging effort. Not only can seismic surveys affect the distribution of marine mammals, but prey distribution may also change. Indirect effects on marine mammals from changes in prey distribution are discussed in **Section 6.2.2.5**.

Management actions and mitigations:

With regards to the potential behavioural impacts on marine mammals during the 18SBB3D Seismic Survey, the following considerations should be noted:

- Behavioural change is predicted at SELs less than 171 dB re 1 µPa2-s. As outlined in Section 6.2.2.1, the SEL of 171 dB re 1 µPa2-s will occur at 1,350 m from the acoustic source, hence behavioural effects are likely during the 18SBB3D seismic survey;
- However, aerial surveys undertaken by Trans-Tasman Resources in the vicinity of the Operational Area from 2011 to 2013 concluded that cetacean density was very low with only one small pod of common dolphins being observed over a total of 4,550 M of line transect (Cawthorn, 2013);
- Any avoidance or displacement will be strictly temporary due to the short operational period (five days) and will cease as soon as the survey ceases;
- Avoidance behaviours could force marine mammals to leave feeding grounds (e.g. large aggregations of krill or fish) as the operating seismic vessel approaches; causing an increase in energy expenditure in order to locate prey aggregations elsewhere;
- Potential displacement of foraging blue whales from krill aggregations in the Operational Area is a concern for any seismic operations in the South Taranaki Bight; however, as noted in **Section 5.2.1.1**, the distribution of blue whales is typically further offshore than the Operational Area. See **Section 6.2.2.5** for discussions about how changes in prey distribution may cause indirect effects on foraging cetaceans; and
- With regard to impacts on migratory behaviour, displacement is unlikely to cause significant energetic consequences in open seas; however, where displacement occurs in confined waterways the consequences may be greater. The most obvious confined water body in the vicinity of the Operational Area is Cook Strait which provides a corridor for blue and humpback whales, primarily in winter months as they migrate north. As the survey will be carried out during summer months, displacement of migratory animals is not expected to occur.

The primary mitigation measures which will be employed to manage marine mammal behavioural effects will be compliance with the Code of Conduct (through the entire Operational Area). In accordance with this:

- Qualified MMOs and PAM operators will be present on the seismic vessel to visually and acoustically scan for marine mammals and to implement the mandatory management actions where necessary (delayed starts and shut downs);
- The specifications of the PAM system proposed for this survey will be assessed by DOC to ensure that it meets the standards described in the Code of Conduct (i.e. as being suitable to detect vocalisations from all Species of Concern that could potentially be in the Operational Area). Full technical specifications of this system are included in **Appendix D**;
- A detailed Marine Mammal Mitigation Plan has been developed to guide operational requirements for the 18SBB3D seismic survey (**Appendix C**);
- STLM has been undertaken to assess the validity of the standard mitigation measures described by the Code of Conduct; and suitable adjustments to mitigation zones have been proposed to reduce the potential for disturbance to marine mammals; and

- Source modelling has been undertaken to ensure that the lowest practical acoustic source volume is used in order to minimise the effects on marine mammals whilst still achieving the data acquisition objectives of the survey.

With these mitigations in place, it is considered that acoustic disturbance will confer risk to marine mammals during the 18SBB3D seismic survey.

6.2.2.3.2 Seabirds

In general there is a lack of information about the behavioural effects of seismic surveys on birds. Goudie and Ankney (1986) suggested that feeding activities could be interrupted by seismic operations. This suggestion was reiterated by MacDuff-Duncan and Davies (1995) who postulated that seabirds in the vicinity of a seismic survey could be alarmed by acoustic disturbance causing them to stop diving. A quantitative study was undertaken by Lacroix et al. (2003) to assess the effect of seismic operations on the foraging behaviour of moulting male long-tailed ducks in the Beaufort Sea. These ducks are incapable of flying during the moult and increase their foraging time during this period to compensate for this nutritionally costly process. Although this species is ecologically quite different from any seabird in New Zealand, the findings of this radio-tracking study provide the first quantitative evidence of behavioural effects from seismic surveys on seabirds. The key findings of this study are outlined below:

- The abundance and distribution of ducks in both seismic and control areas changed similarly following the start of seismic operations suggesting that other influencing factors (e.g. wind) were more important than seismic activities;
- Seismic activity did not significantly change the diving intensity of ducks; and
- The data collected provided no evidence to suggest any displacement away from active seismic operations.

While the Lacroix et al. (2003) study failed to clearly demonstrate a response to seismic activity, the statistical power to detect a response was considered to be relatively low and the authors concluded that additional studies on other species of birds are needed to fully understand the effects of seismic operations on seabird behaviour.

In addition to behavioural disruptions, the displacement of seabird prey species could also theoretically lead to a reduction in seabird diving activities and foraging potential around an operating seismic vessel. Pichegru et al. (2017) investigated the response of breeding African penguins to seismic operations near penguin colonies using GPS tracking. The results of this study showed strong avoidance of the seismic vessel; whereby individuals did not use preferred foraging areas when seismic surveys were active nearby. Birds reverted to normal behaviours as soon as operations ceased.

<u>Management actions and mitigations:</u>

Despite the identification of potential impacts, any disturbance to seabirds during the 18SBB3D seismic survey would be strictly temporary and localised in nature and no specific mitigation measures are in place to reduce these potential effects. The potential risk to seabirds is considered to be.

6.2.2.3.3 Marine Reptiles

It is unlikely that any marine reptiles will be present within the Operational Area during the 18SBB3D seismic survey (**Section 5.2.4**). However, patterns of avoidance and behavioural responses have been observed in sea turtles in response to seismic surveys. McCauley et al. (2000) exposed captive sea turtles (a loggerhead turtle and a green turtle) to an approaching acoustic source; to which the turtles displayed a behavioural response of an increase in swimming speed at a received level of 166 dB re 1 µPa rms and an avoidance response of erratic swimming around 175 dB re 1 µPa rms. For a 3D seismic survey in 100 – 120 m water depth, this typically relates to behavioural changes at 2 km and avoidance at 1 km. De Ruiter and Doukara (2012) also documented avoidance behaviours for loggerhead turtles exposed to seismic operations (with a peak source level of 252 dB re 1 µPa). Here turtle dive probability decreased with increasing distance to the acoustic source, where a dive response was interpreted as avoidance behaviour.

<u>Management actions and mitigations:</u>

In the unlikely event that a turtle is present in close proximity to the operational seismic vessel, some avoidance may occur. No specific mitigation measures are in place for sea turtles, however, due to the unlikely occurrence of turtles (and sea snakes) in the Operational Area and the relatively short-term nature of the survey, it is considered that the risk of behavioural effects to marine reptiles will be **negligible**.

6.2.2.3.4 Fish and Fisheries

Studying the behavioural response of wild fish to underwater noise is difficult; hence investigations have typically involved the assessment of fisheries catch-effort data before and after a seismic survey. Alternatively, caged fish can be exposed to an acoustic source, although in these circumstances behavioural observations are potentially biased by the fact that the subjects are constrained, reducing their ability to exhibit avoidance behaviours that would otherwise be possible in the wild. In addition, captive studies typically only provide information on behavioural responses of fish during and immediately after the onset of the noise (Popper & Hastings, 2009). Another factor to consider is the variability in experimental design between projects (e.g. source level, duration, location etc.) and the subjects of exposure (e.g. species, wild/caged, demersal/pelagic, migrant/site-attached, age etc.) often make it difficult to draw overall conclusions and comparisons.

Despite these limitations, the following short-term responses have been observed for fish species:

- Startle responses (Pearson et al., 1992; Wardle et al., 2001; Hassel et al., 2004; Boeger et al., 2006);
- Modification in schooling patterns and swimming speed (Pearson et al., 1992; McCauley et al., 2000; Fewtrell & McCauley, 2012);
- Freezing (Sverdrup et al., 1994); and
- Changes in vertical distribution within the water column (Pearson et al., 1992; Fewtrell & McCauley, 2012).

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

In addition to these findings, other studies have failed to detect any changes, e.g. Peña et al. (2013) observed no changes in swim speed, direction or school size of herring in response to a six hour exposure to a full-scale 3D seismic survey, and Hassel et al. (2004) also found evidence of habituation to underwater noise through time.

The only evidence of a long-term behavioural effect from a seismic survey was noted by Slotte et al. (2004) who investigated the distribution and abundance of herring and blue whiting during a commercial 3D seismic survey off the Norwegian coast. During this study fish distribution was mapped acoustically within the seismic area and in the surrounding waters (up to 30 – 50 km away). The acoustic abundance of pelagic fish was consistently higher outside the seismic area than inside which the authors interpreted to be an indication of long-term displacement.

It is well recognised that commercial fishing operations may also suffer indirect effects on account of the behavioural responses of fish to seismic surveys (e.g. McCauley et al., 2000). Reductions in catch per unit effort for commercial fishing vessels operating close to seismic operations have been demonstrated (Skalski et al., 1992; Engas et al., 1996; Bendell, 2011; Handegard et al., 2013), with effects lasting up to five days following the conclusion of seismic operations. However, no evidence of longer term displacement has been reported. Bendell (2011) considered long-line catches off the coast of Norway during the acquisition of a two week seismic survey with a peak source level of 238 dB re 1µPa@1m. Catch rates reduced by 55 – 80% within 5 km from the active source, although these reductions were temporary; catch rates returned to normal within 24 hours of seismic operations ceasing (Bendell, 2011). Streever et al. (2016) reported significant changes to catch rates (both increases and decreases) in response to seismic surveys in Prudhoe Bay, Alaska and postulated that these changes were a result of fish displacement where acoustic source activity could increase or decrease catches depending on the location and timing of the fishing effort in relation to the seismic survey.

In other instances no evidence has been found to suggest that seismic surveys affect commercial fisheries. For example the distribution of bass was documented during a long-term seismic survey (duration of three and a half months) operating at a peak source of 202 dB re 1µPa@1m. During this study no long-term changes in distribution were observed, and tagged fish recaptures demonstrated that there were no large scale emigrations from the survey area (Pickett et al., 1994). Similarly, a study in the Adriatic Sea reported no observed changes in pelagic biomass following an acoustic disturbance with a peak of 210 dB re 1µPa@1m, indicating that catch rates were unlikely to be affected (Labella et al., 1996). A case study on catch rates around the Faroe Islands also noted that although fishers perceived a decrease in catch during seismic operations, their logbook records during periods both with and without seismic operations revealed no statistically significant effect compared to periods with acoustic disturbance (Jakupsstovu et al., 2001).

Management actions and mitigations:

Based on the examples above, some short-term distributional changes for fish are possible during the 18SBB3D seismic survey; hence displacement of commercially valuable fish stocks from the Operational Area may occur. The evidence presented in this section suggests that in some circumstances displacement reduces catch rates while in other circumstances it increases catch rates. It is difficult therefore to predict how catch rates of the commercial fisheries operating in Taranaki waters will be impacted by the proposed survey.

During the 18SBB3D seismic survey behavioural effects on fish will be managed by the use of soft starts and continuous operations to minimise the duration of any effects. In addition, commercial fishers have been advised of the proposed operations and will be informed of the predicted start date closer to the time. With these mitigation measures in place it is considered that the risk of behavioural disturbance to fish and the consequences to fisheries during the proposed seismic survey is**.**

6.2.2.3.5 Cephalopods

Behavioural changes have been documented for cephalopods (squid and octopus species) in response to acoustic disturbance. Caged cephalopods that were exposed to acoustic sources demonstrated a startle response above 151-161 dB re 1 µPa and tended to avoid acoustic disturbance exhibiting surface behaviours (McCauley et al., 2000). Soft-starts effectively decreased the startle response during this study. A subsequent study corroborated these findings and further demonstrated that a source level of 147 dB re 1 µPa was necessary to induce an avoidance reaction in squid. Throughout this experiment, other reactions were also observed including alarm responses (inking and jetting away from the source), increased swimming speed and aggressive behaviour. It was noted that the reaction of the animals decreased with repeated exposure to the sound suggesting either habituation or impaired hearing (Fewtrell & McCauley, 2012). McCauley et al. (2000) suggested that thresholds affecting squid behaviour occur at 161-166 dB re 1 µPa rms.

Management actions and mitigations:

It is likely that squid will avoid the immediate vicinity during the 18SBB3D seismic survey. Behavioural effects will be managed by the use of soft starts and continuous operations to minimise the duration of any effects. With these mitigation measures in place it is considered that the risk of behavioural changes to cephalopods during the 18SBB3D seismic survey is.

6.2.2.3.6 Benthic Invertebrates

Crustaceans

Limited data is available on the behavioural responses of crustaceans to seismic surveys; however, the following is a summary of the available information.

A field experiment was conducted in Tasmania to assess behavioural effects of a 150 in^3 acoustic source on red rock lobster (Day et al., 2016). The key finding of this study was that seismic exposure was found to significantly increase righting time in lobsters that had been placed on their backs. This effect could potentially increase predation rates of exposed individuals (Day et al., 2016).

Indirect effects on crustacean fisheries have also been assessed:

- Catch rates of three species of shrimp (southern white shrimp, southern brown shrimp and Atlantic seabob) were not affected by a seismic survey with a peak source level of 196 dB re 1 µPa at 1 m (Andriguetto-Filho et al., 2005); and
- Lobster catch rates showed no significant change during the weeks and years following seismic surveys in Western Victoria, Australia (Parry & Gason, 2006). In this study, the number of seismic pulses was correlated to catch per unit effort data over 12 depth stratified regions. Data was analysed over a 25 year period during which 28 seismic surveys (2D and 3D) occurred.

In New Zealand, the red rock lobster (commonly known as crayfish) is important from a commercial, cultural and recreational fisheries perspective. They are found in coastal subtidal reefs and therefore commercial fishing for this species is limited to the territorial sea where it is concentrated on the eastern and southern coasts of New Zealand (MFish, 2016). The 18SBB3D seismic survey overlaps with the territorial sea; therefore some effects on red rock lobster could occur in areas of habitat overlap. However, given the findings of the studies above, these effects are unlikely to cause significant detrimental impacts on the red rock lobster fishery.

Although scampi and deep-water crabs are also commercially harvested in New Zealand, there is no overlap with these fisheries and the Operational Area; scampi are targeted to the east of the North Island, the Chatham Rise, and the Auckland Islands, while deep-water crabs are targeted in water depths deeper than those found in the Operational Area.

Shellfish

As with crustaceans, little information exists with regards to the behavioural effects of seismic surveys on shellfish. Day et al. (2016) assessed the behavioural response of scallops to seismic exposure and found that seismic exposure increased the rate that scallops recessed themselves into the sediment, but that exposed scallops were slower at righting themselves than control scallops. The authors state that the ecological implications of these results require further study but that the slowed righting response could lead to higher predation rates.

Management actions and mitigations:

Coastal shellfish beds are of social and cultural significance along the Taranaki coast. However, harvestable shellfish habitat is very much limited to sheltered, shallow, coastal waters inshore of the Operational Area. Hence no overlap is predicted between harvestable shellfish beds and the proposed seismic operations. Based on the information above, the potential effect of acoustic disturbance on benthic invertebrates and associated fisheries is considered to be **minor**.

6.2.2.4 Potential Perceptual Effects

Perceptual effects typically refer to the concept of 'masking' which occurs when anthropogenic noise interferes with the ability of an animal to detect or respond to biologically relevant sounds. Masking can be either complete (when the signal is not detected at all) or incomplete (when the signal is detectable but the content is hard to understand) (Clark et al., 2009). Masking has been documented for both marine mammals and fish and is discussed below.

6.2.2.4.1 Marine Mammals

Marine mammals rely on sound for a range of functions including foraging, navigation, communication, reproduction, parental care, avoidance of predators, and to gain an overall awareness of the surrounding environment (Thomas et al., 1992; Johnson et al., 2009). The ability to perceive sound is therefore crucial to marine mammals. The likelihood of masking is determined by how much overlap occurs between marine mammal vocalisations and anthropogenic sounds; the frequency of the two competing sounds is particularly important (Richardson et al., 1995). The frequencies of marine mammal vocalisations (for communication and echolocation) are presented in **Table 26,** and **Figure 29** indicates which cetacean vocalisations are most at risk of overlap with marine seismic surveys.

Table 26 Cetacean Communication and Echolocation Frequencies

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

Source: Summarised from Simmonds et al, 2004

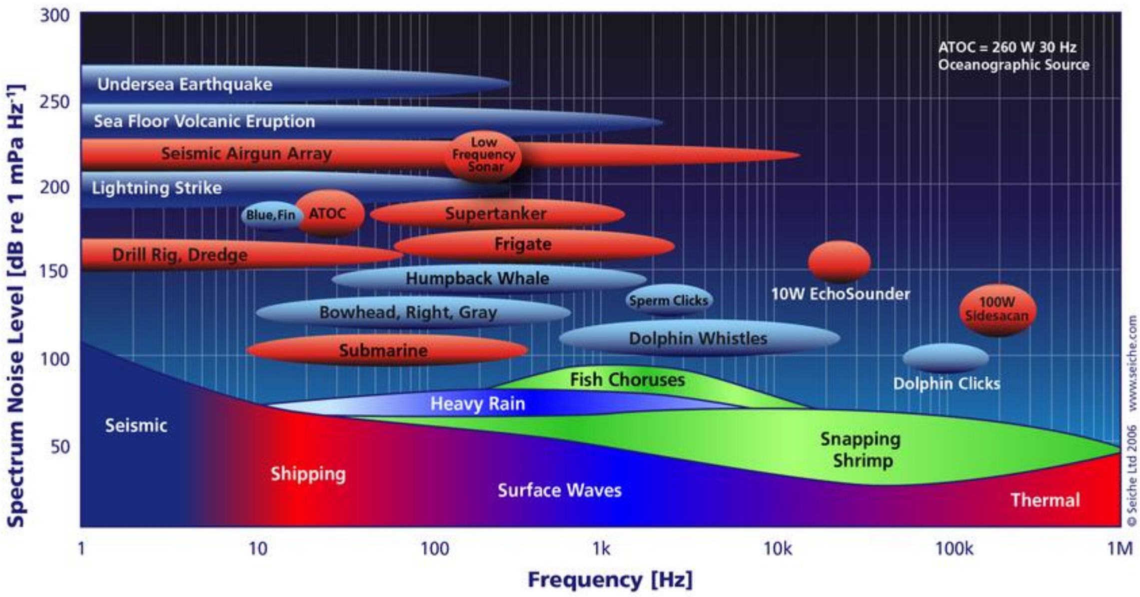
Key:
nd = no data available
* = using the bottlenose whale as an example
** = Kyhn et al, 2009
*** = Au and Wursig, 2004

Cetacean species are categorised into three functional hearing groups depending on the frequencies of their vocalisations (Southall et al., 2007):

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

Acoustic sources during seismic surveys emit broadband frequencies, with the majority of energy concentrated between 0.1 kHz and 0.25 kHz. Therefore, the greatest potential for a seismic source to interfere with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum. This means that the lowest frequency cetaceans (i.e. the baleen whales) are likely to be most affected by 'masking' as the seismic acoustic source has the greatest potential to overlap with these low frequency vocalisations (**Figure 29**). Vocalisations of mid and high frequency cetaceans are less likely to be masked.

Figure 29 Ambient and Localized Noise Sources in the Ocean



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

In the presence of anthropogenic underwater noise, marine mammals have in some instances adapted their calls to increase audibility. Examples of adaptive behaviours include changes in vocalisation strength, changes in vocalisation frequency, and changes in vocalisation timing (McCauley et al., 1998; Lesage et al., 1999; McCauley et al., 2003; Nowacek et al., 2007; Di Iorio & Clark, 2009; Parks et al., 2011). For example, blue whale calls during social encounters and feeding increased when a seismic survey was occurring nearby (Di Iorio & Clark, 2009). The calling rates of bowhead whales near a seismic survey were however found to vary with changes in received SELs (Blackwell et al., 2015). In this study, at very low SELs (only just detectable) calling rates increased. As SELs continued to increase, calling rates levelled off (as SELs reached 94 dB re 1µPa^2-s), then began decreasing (at SELs greater than 127 dB re 1µPa^2-s), with whales falling virtually silent once SELs exceeded 160 dB re 1µPa^2-s. Hence adaptations to masking for some species may be limited to circumstances when whales are subject to only low to moderate SELs. While our understanding of the sound pressure component of whale vocalisations is reasonable, Mooney et al. (2016) demonstrated that acoustic fields generated by singing humpback whales include significant particle velocity components as well and these are also detectable over long distances. Further research is warranted with regard to the role that particle motion plays in whale communication and how anthropogenic noise might affect this.

Recent reseach has indicated that some species of toothed whale can moderate the sensitivity of their hearing to muffle loud noises. To date this ability has been demonstrated for a small number of captive false killer whales, bottlenose dolphins, harbour porpoises and beluga whales (as summarised by Hickok, 2017). These finding suggest that some species at least may be able to shield themselves naturally from loud underwater noises. More research is needed to fully understand this observation.

Management actions and mitigations:

Based on the information presented above, it is possible that calls of baleen whales in the South Taranaki Bight could be masked as a result of the proposed seismic operations, however the STLM results indicate that at distances greater than 100 km from the source and in some areas within 100 km of the survey the SELs will be about the same as, or marginally above, ambient oceanic noise levels (see **Figure 27**) (where ambient oceanic noise is typically around 100 dB; see **Table 1** and **Figure 29**). No specific mitigation measures are in place to manage any such perceptual effects as the Code of Conduct requirements focus solely on physiological and behavioural impacts. On this basis, the risk of marine mammals suffering perceptual effects is considered to be **moderate**.

6.2.2.4.2 Fish

Many fish species produce sounds as a form of communication; these vocalisations are typically within a frequency band of 100 Hz and 1 kHz (Ladich et al., 2006; Bass & Ladich, 2008). Although no data exists for the effect of seismic surveys on fish masking, other anthropogenic sounds, such as boat noise, has reportedly caused masking in fish (e.g. Picciulin et al., 2012). It is therefore reasonable to assume that the acoustic source of a seismic survey could cause similar communication challenges. For fish species with good hearing Popper et al. (2014) demonstrated that there is a greater likelihood of masking further from the acoustic source than close to it.

Radford et al. (2014) suggest five ways in which fish might adapt to masking:

- Avoidance of noise. This can occur either spatially or temporally. E.g. silver perch vocalise less frequently when recordings of a predator were played (Luczkovich et al., 2000);
- Temporal adjustments. Signal detection enhances as signal duration increases. E.g. male toadfish increase their call rate in the presence of rival males (Fine & Thorsen, 2008);
- Amplitude shifts. In noisy environments an increase in amplitude increases signal detection (the Lombard Effect);
- Frequency shifts. Broadband sounds are more difficult to detect in a noisy environment than pure tones. E.g. freshwater gobies in waterfall habitats produce vocalisations in a frequency that differs from that of the waterfall noise (Lugli et al., 2003); 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.

Little is known about fish vocalisations for marine fishes in New Zealand; however in line with the precautionary principle it is reasonable to assume that the SouthTaranaki 3D Seismic Survey may lead to masking for some fish species.

Management actions and mitigations:

As masking of fish communication by anthropogenic sound has been demonstrated, the risk of masking of fish from the 18SBB3D seismic survey is considered to be **moderate**.

6.2.2.5 Potential Indirect Effects

As well as the direct effects discussed in the sections above, animals may also suffer from indirect effects of noise exposure during seismic surveys. Potential 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).

With regard to changes in prey distribution and abundance, it is important to understand that the distribution of marine mammals is typically linked to that of their prey (see Fielder et al., 1998), therefore avoidance of the seismic vessel could lead to abandonment of valuable feeding grounds or reduced foraging efficiency. Despite such indirect effects having the potential to be significant, they are much more difficult to detect and measure than direct effects and are likely to vary with species, individuals, age, sex, past exposure and behavioural state (IWC, 2007).

Whilst planning for seismic operations in the South Taranaki Bight, particular consideration must be given to the potential indirect effects that changes in krill availability (distribution and abundance) could have on pygmy blue whales here. From the information presented in **Section 6.2.2.2.7** we know that the distribution and abundance of krill larvae can change in the immediate vicinity (within approximately 2.5 km) of an active seismic source (McCauley et al., 2017; Richardson et al., 2017). While no information is available about the effects of seismic operations on adult krill, the documented effects on larve could presumably have flow-on effects and may reduce recruitment rates into the adult population in surrounding waters. However, until the mechanism for the observed change in krill larvae is understood, flow-on effects are speculative at best.

Pygmy blue whales are known to target krill (*Nyctiphanes australis)* as their primary prey in the South Taranaki Bight (Torres et al., 2015). Krill concentrations occur in association with upwellings of cold nutrient rich water. The fine-scale distribution of krill, and therefore pygmy blue whales, varies both within years and between years depending on the location and intensity of these upwelling events (Torres & Klinck, 2016).

In recent years, feeding aggregations of pygmy blue whales have typically occurred to the southwest of the Operational Area (see Torres et al., 2017 and **Section 5.2.1.1**) hence the potential for direct spatial overlap between the 18SBB3D seismic survey and blue whales is considered to be relatively low. Yet given the high levels of public interest in this topic and the inter-annual variability, it is important to consider the potential for impacts in the event that blue whales are observed during the proposed operations. Pygmy blue whales have been recorded in the South Taranaki Bight during all months of the year, with mother/calf pairs present during summer (Torres & Klinck, 2016). Therefore prey availability over summer could be particularly important.

Richardson et al. (2017) reported that zooplankton populations recovered quickly after seismic exposure due to their fast growth rates, and the high rates of dispersal and mixing of zooplankton in the offshore marine environment. While this is encouraging it does not completely remove the possibility that krill availability may be reduced in the feeding habitat of pygmy blue whales in the South Taranaki Bight during the 18SBB3D seismic survey and that any individuals present (including mother and calf pairs) could be subject to energetic costs associated with reduced foraging efficiency.

As the distribution and abundance of fish can also change in response to exposure to underwater noise (e.g. Pearson et al., 1992; McCauley et al., 2000; Colman et al., 2008; Handegard et al., 2013), indirect effects could also affect predatory fish species and piscivorous marine mammals during seismic operations.

Management actions and mitigations:

While the discussion above clearly identifies some potential for indirect effects of seismic surveys on marine predators, quantification of such effects is virtually impossible on account of the numerous variables that affect prey availability at any one time. Until such effects can be quantified and predicted then it is challenging to propose any targeted management measures to avoid, remedy or mitigate indirect effects. It is encouraging however that few blue whale sightings have occurred in the Operational Area in the past and that feeding aggregations of blue whales have been to the southwest over recent summers. Any indirect effects that do occur during the 18SBB3D seismic survey will be temporally limited on account of the short duration of the proposed operational activities. In summary, the risk of indirect effects from the 18SBB3D seismic survey is considered to be.

6.2.3 Waste Discharges and Emissions

The survey vessels will produce the following forms of waste during the 18SBB3D seismic survey:

- Biodegradable wastes;
- Non-biodegradable wastes; and
- Atmospheric emissions from exhausts.

Inappropriate discharges of such wastes have the potential to cause adverse effects on the surrounding environment. The volume of waste produced during the survey depends on a number of factors, but mainly the number of personnel onboard the vessels and duration of the survey.

All produced wastes will be managed in accordance with TEMS environmental practices and MARPOL requirements (as enacted by the Marine Protection Rules for any operations within the EEZ) and the Resource Management (Marine Pollution) Regulations 1998 (for operations within the territorial sea).

6.2.3.1 Potential effects from biodegradable waste

Biodegradable wastes produced during a seismic survey include black water (sewage/faecal waterwater from toilets), greywater (wastewater from sinks, showers, laundering, etc), galley wastes and oily water (from bilges). Once discharged to the marine environment these wastes undergo a bacterial decomposing process either in the water column or on the seabed. There are two consequences to this process (Perić, 2016; Wilewska-Bien et al., 2016):

- Oxygen is required for bacteria to break down the waste, resulting in an increase in the local oxygen demand which, in turn, can lead to a depletion of the oxygen concentration in the surrounding waters; and
- Nitrogen and phosphorous are released and introduced into the surrounding environment.

As a result of these two processes oxygen can become limited for marine organisms, particularly in areas of low flow and restricted mixing, and the addition of nitrogen and phosphorous can enrich the surrounding environment leading to (potentially toxic) algal blooms. Black water and grey water may also contain a number of pathogens detrimental to human health such as *Salmonella* and gastro-intestinal viruses (Perić, 2016; Wilewska-Bien et al., 2016), while ground food waste can provide a food source for larger organisms such as fish (Wilewska-Bien et al., 2016).

Galley waste will only be discharged at sea if it is in the form of biodegradable food scraps (see **Section 6.2.3.2** for the handling of non-biodegradable wastes). Such discharges will occur in accordance with the New Zealand Marine Protection Rules. These rules stipulate that food scraps will only be discharged to sea at distances greater than 12 M seismic from land. At distances between 3 and 12 M from land, biodegradable wastes may only be discharged once comminuted to less than 25 mm.

All vessels involved in the 18SBB3D survey will have onboard sewage treatment plants. All sewage and grey-water will receive a high level of treatment before being discharged. Where applicable, vessels will hold an International Sewage Pollution Prevention Certificate.

Oily waters are generally derived from the bilges. All survey vessels will have bilge water treatment systems that ensure any discharges are below the required 15 ppm of oil content before discharge.

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

The risk from routine discharges of biodegradable waste during the 18SBB3D seismic survey is considered to be **negligible**.

6.2.3.2 Potential effects from non-biodegradable waste

When discharged into the marine environment non-biodegradable wastes/garbage, for example plastics used in food wrapping and packaging, can have severe detrimental effects on marine fauna. Effects include entanglement, ingestion of foreign objects (leading to internal injury, blockage of intestinal tracts, and a reduction in fitness etc.), and accumulation of debris on the seabed and water column (Derraik, 2002). Various species of seabirds, fish, turtles, and marine mammals have all been found with plastics in their gut contents (Derraik, 2002). Non-biodegradable wastes persist in the marine environment for extensive periods of time and may be transported large distances (Li et al., 2016).

All non-biodegradable wastes produced during the 18SBB3D seismic survey will be stored onboard the vessel and returned to shore for disposal in adherence to local waste management requirements. Chain of custody records will be retained.

The environmental risk of any non-biodegradable discharges to the marine environment is considered to be.

6.2.3.3 Potential effects from atmospheric emissions

Combusted exhaust gasses produced by internal combustion engines in the form of carbon dioxide and carbon monoxide are the primary source of atmospheric emissions during the 18SBB3D seismic survey. Other toxic inorganic gasses such as nitric oxide and nitrogen dioxide are also produced (Steiner et al., 2016); however, these will be in much smaller quantities. Emissions of carbon dioxide (and other gasses) are classed as greenhouse gas emissions and are linked to climate change. Combusted exhaust gasses can also reduce the ambient air quality. This is particularly problematic for populated areas, where human health issues may arise such as pulmonary disease, cardiovascular disease and cancer (Steiner et al., 2016).

The survey vessels will hold International Air Pollution Prevention Certificates, ensuring that all engines and other equipment are regularly serviced and maintained. The use of low sulphur fuel is also common place on seismic vessels, serving to reduce atmospheric emissions. On this basis, the environmental risk of atmospheric emissions is considered to be.

6.2.4 Cumulative Effects

‘Cumulative effects’ occur when effects from multiple sources combine. In the case of the 18SBB3D seismic survey, other underwater noise sources may be operating concurrently in and around the Operational Area to increase the overall underwater sound profile above that which would be expected from the seismic survey alone. Techniques to quantify cumulative effects are in their infancy; however, in this section we provide a general discussion on possible cumulative effects during the proposed operations. Noise from other seismic surveys and shipping traffic are of particular interest as these are two potential contributors to cumulative effects of underwater noise in Taranaki waters.

<u>Shipping Traffic</u>

With regards to potential shipping traffic in and around the Operational Area, **Section 5.6.2** describes how the Operational Area overlaps with the shipping lanes between Port Taranaki, Whanganui and destinations in the top of the South Island. Hence shipping noise is an ongoing, but unquantified component of the sound scape in the Operational Area.

Di Iorio and Clark (2009) investigated the calling rates of blue whales during a seismic survey in relation to periods when the seismic source was active and during other times when normal background shipping noise was present, but seismic outputs were absent. The authors noted an increase in call rate associated only with periods when seismic was active; therefore excluding shipping noise as a causative factor in call rate changes.

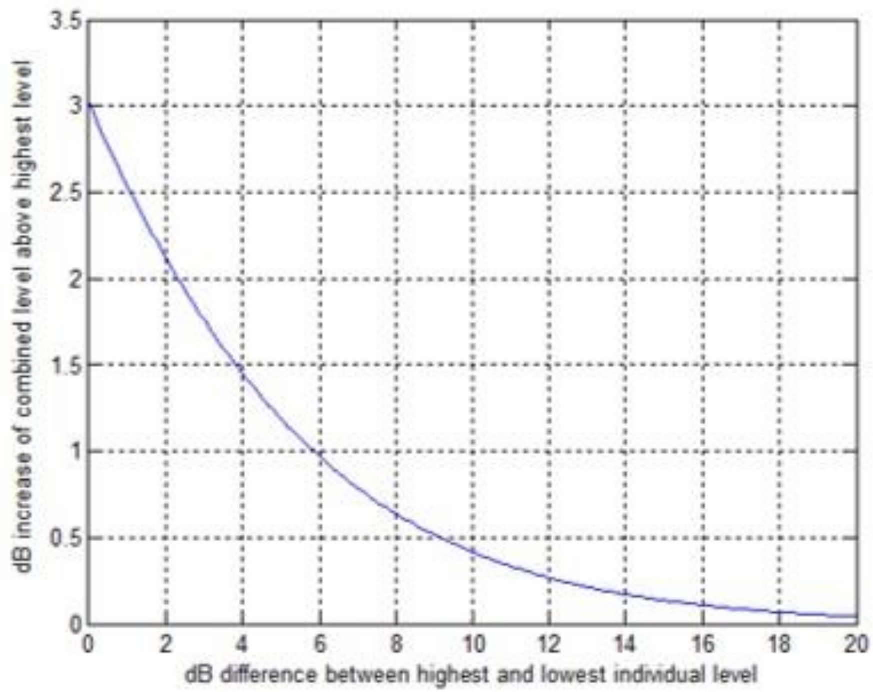
In areas where shipping levels are relatively low, the combination of a seismic survey with shipping noise could result in greater disturbance to marine mammals than from either activity in isolation. In these circumstances, the masking effects could occur over relatively large areas given the low frequency nature of shipping and seismic noises which propagate over long distances. Coastal and offshore Taranaki waters are used on a frequent basis by ships in transit. Hence shipping noise is considered an existing feature in offshore Taranaki waters and is unlikely to contribute significantly to masking of resident marine mammals.

In the presence of consistent noise, marine mammals sometimes adapt their vocalisations in order to mitigate against the effects of masking (e.g. McGregor et al., 2013). These studies support the notion that the most significant masking effects can be expected in areas where baseline noise levels are typically low.

Seismic Surveys

When acoustic outputs from two different seismic surveys combine the outcome is counter-intuitive; whereby the largest difference between the combined and individual SELs will be 3 dB re 1µP²s, and this will only occur at locations where both surveys produce the same SEL's. In other words, if at a given location, Survey A by itself would produce a SEL of 160 dB re 1µP²s, and Survey B by itself would also produce an SEL of 160 dB re 1µP²s, then the two surveys combined will produce an SEL at the same location of 163 dB re 1µP²s (Alec Duncan pers. comm.). However, if one survey produces a higher SEL, then the higher SEL will dominate to the point where if Survey A produces an SEL of 6 dB re 1µP²s higher than Survey B, then the combined level is 1 dB re 1µP²s higher than the higher of the individual SELs (i.e. Survey A) (**Figure 30**).

Figure 30 Combined Sound Exposure from Two Seismic Sources



Source: pers. comm. Alec Duncan

Cumulative impacts are much more likely to occur when two surveys are operating close together in time or space (or both). It is considered that a cetacean may be able to reorient and cope with a single sound source emitted from a seismic survey, but may be less able to cope with multiple sources; however, this is still unproven.

TEMS is aware of two other seismic surveys occurring in the Taranaki Basin early in 2018; these being the 'Schlumberger Western Platform Multi-Client 3D Seismic Survey' and the 'Shell Taranaki Limited Māui 4D Seismic Survey'. These surveys however, will be acquired by the same seismic vessel, the *MV Amazon Warrior*, hence there will be no temporal overlap of seismic operations in the Taranaki Basin.

The potential for three consecutive surveys in the Taranaki Basin does however exist; with the cumulative operational period extending up to five months (from December 2017 to April 2018). The duration of the 18SBB3D seismic survey is the shortest of the three surveys (five days, as compared to three months for the Schlumberger survey and 40 days for the Shell Taranaki survey). Although the risk of cumulative effects is driven by the cumulative duration of all three surveys; it is noteworthy that the 18SBB3D seismic survey is significantly shorter than both the other surveys that could occur.

In addition, the *RV Marcus Langseth* will be operating a seismic survey from Fiordland to the Puysegur Trench in early 2018. Based on the relative geographical isolation of these areas from the Operational Area, there is unlikely to be any overlap in the sound fields of the surveys.

<u>Management actions and mitigations:</u>

Marine environments differ in their resilience to anthropogenic stressors (Ban et al., 2010). The potential for cumulative effects is also likely to be related to physical features such as depth, bathymetry and coastline shape. Shallow enclosed waters are at higher risk than open ocean settings as the attenuation potential is lower in enclosed water bodies. The open water nature of the 18SBB3D seismic survey reduces the risk associated with potential cumulative effects. Resident populations will be more sensitive to cumulative impacts than will migratory or non-resident populations (i.e. humpback whales).

As the management of acoustic effects of seismic surveys is already managed to 'as low as reasonably practicable' through the Code of Conduct requirements and the duration of the 18SBB3D seismic survey is as short as possible, meaning the incremental contribution of this survey to cumulative effects will be limited, no specific additional mitigation measures are available to address cumulative effects of sequential surveys sustained over about 5 months. On this basis, the environmental risk of cumulative effects across the wider South Taranaki Bight is considered to be. It is worth bearing in mind that at distances greater than 100 km from the survey in the South Taranaki Bight the SELs from this survey are likely to be the same as, or only marginally above, ambient noise levels in the ocean.

6.3 Unplanned Events

During the 18SBB3D seismic survey there is the potential for the following unplanned events to occur:

- Introduction of invasive marine species;
- Streamer loss;
- Hydrocarbon spill; and
- Vessel collision/sinking.

While the occurrence of unplanned events is unlikely, any potential effects of such incidents can be severe and should be given serious consideration.

6.3.1 Potential Effects of Invasive Marine Species

International vessel movements are generally considered the main causes of the spread and introduction of exotic marine species, with transportation of organisms usually occurring as part of biofouling on hulls, anchor chains and in sea chests, or in ballast and bilge water (Bax et al., 2003; Fletcher et al., 2017). An exotic species is considered to be ‘invasive’ once it begins to cause negative consequences in the new environment (Bax et al., 2003). Once established in the marine environment, invasive species are difficult to manage or eradicate (Fletcher et al., 2017). Potential effects of the introduction of invasive species include:

- Ecological impacts - changes in function and composition of native biological communities; and
- Economic impacts on economically important sectors (e.g. aquaculture, tourism, and fisheries) (Fletcher, et al. 2017).

Mitigation measures against the introduction of invasive marine species during the 18SBB3D seismic survey include:

- The implementation of management measures to ensure the vessel meets the clean hull requirement of the Craft Risk Management Standard – Biofouling on Vessels Arriving to New Zealand; and
- Adherence to the Import Standard for Ballast Water Exchange.

Given the vessel will have been in New Zealand for two months by the time it commences the 18SBB3D survey, the introduction of invasive species attributable to this particular survey is unlikely. The potential risk of introducing invasive marine species is therefore considered to be

6.3.2 Potential Effects of Streamer Loss

Seismic streamers can be severed and lost following events such as snagging on floating debris, shark bites, abrasion, and vessel collision. As the streamers are negatively buoyant they would sink if severed. Therefore, if a streamer is lost there is potential for the severed portion to make contact with the seabed; where it could accumulate as anthropogenic debris and affect benthic communities. Any contact with the seafloor could also have potential effects on marine archaeology, cultural heritage or submarine infrastructure.

Towed streamers will be fitted with tail buoys containing lights and a radar reflector to mark the end of the streamer lines and to alert other marine users to the location of the streamers. The streamers used in the 18SBB3D seismic survey are fitted with self-recovery devices. These devices are programmed to activate at a pre-determined depth, returning the severed streamer back to the sea surface for retrieval.

In the event that a streamer does make contact with the seafloor, it is useful to note that areas of archaeological interest or cultural significance are typically associated with intertidal and subtidal coastal environments, instead of offshore areas like those in the Operational Area.

The 18SBB3D seismic survey will be undertaken by experienced personnel; this, coupled with the use of self-recovery devices means that if a streamer was lost the environmental risk would be.

6.3.3 Potential Effects of Hydrocarbon Spills

Hydrocarbon spills in the marine environment can have a number of detrimental effects on marine animals and ecosystems, as well as economic, social, and recreational effects. The effects of hydrocarbon spills are well known and include, but are not limited, to the following (Moore & Dwyer, 1974; as summarised in McConnell, 2014):

- Toxicity effects: direct and indirect (does not cause immediate death, although mortality may follow due to abnormal behaviour or other indirect causes (Moore & Dwyer, 1974), and sub-lethal population effects such as disruption of feeding behaviours, physical damage (e.g. burns and ulcers), immunosuppression, and impaired reproduction;
- Removal and damage to, or exclusion from habitats and other important areas (e.g. areas used for feeding, resting, migrating and breeding);
- Bioaccumulation in fauna, particularly molluscs;
- Long-term disruption of food chains and predator/prey interactions;
- External oiling on marine mammals and seabirds leading to loss of waterproofing, buoyancy, swimming ability, filtering capabilities (such as by baleen whales) and thermoregulatory abilities, and toxicity effects via internal contamination if inhaled/ingested; and
- Exclusion of users of the marine environment due to contamination/tainting of edible species or altered perception.

The severity and range of effects in a species depends on a number of factors, for example nature of the spilt substance (i.e. diesel, petrol, crude oil) and the sensitivity of particular species/individuals (Moore & Dwyer, 1974).

Incidents while refuelling at sea, leakages from storage areas or equipment, and rupture/failure of the hull or fuel tank are potential causes of a hydrocarbon spill during the 18SBB3D seismic survey. Of these causes, a refuelling incident at sea is the most likely, with hose ruptures, coupling failures, and tank overflow having the potential to result in a spill. Refuelling of the seismic vessel at sea is unlikely to occur on account of the relatively short duration of the survey. However, if refuelling at sea is necessary, a detailed refuelling protocol will be in place which will outline the procedures to be followed during refuelling operations. During refuelling the following mitigation measures and management actions will be adhered to in order to prevent a spill:

- Refuelling will only be undertaken during daylight hours and in sea conditions that have been deemed appropriate by the vessel master/s;
- Prior to each fuel transfer a Job Hazard Analysis (or equivalent) will be in place and reviewed by all parties participating in the refuelling;
- All transfer hoses will be fitted with ‘dry-break’ couplings (or similar). These will be checked for integrity before each use/fuel transfer;
- Emergency spill response kits will be maintained and located in close proximity to hydrocarbon refuelling, storage, and bunkering areas;
- Refuelling operations will be continuously manned throughout, with constant visual monitoring of equipment such as gauges, hoses, fittings and the sea surface (to identify any spill/leak); and
- Radio communication will be maintained between all vessels involved in refuelling operations.

The support vessel will not be refuelled at sea, and will instead refuel at Port Taranaki.

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

In the event of a hydrocarbon spill, a spill response will initially be undertaken in accordance with the Shipboard Oil Pollution Emergency Plan, and notification will be provided to Maritime New Zealand and the appropriate local authorities (e.g. Taranaki Regional Council).

The maximum possible hydrocarbon volume to be spilt relates to each vessels fuel carrying capacity and would only occur in the extremely unlikely event of hull or fuel tank failure. The maximum possible volume spilt by the *MV Amazon Warrior* would be 3,941t. Measures in place to ensure that the risk of such a spill is minimised include:

- The use of high-tech navigational systems on board all vessels (e.g. radar detector, GPS, marine radio etc.);
- Adherence to the COLREGS;
- Other marine users will be notified of the seismic survey; and
- Operational procedures that are aligned with international best practice.

Based on the information presented above and the mitigation actions in place, it is considered that the risks of effects from a hydrocarbon spill during refuelling are, but the risks of a fuel tank rupture onboard the *MV Amazon Warrior* are.

6.3.4 Potential Effects from Vessel Collision or Sinking

In the event of a vessel collision, the biggest threats to the environment would be 1) the vessel sinking and settling on the seafloor, 2) pollution to the marine environment through the spread of debris, and 3) the release of hazardous substances (see **Section 6.3.3** for effects of hydrocarbon spills).

The following mitigation measures and management actions will be adopted during the 18SBB3D seismic survey to minimise the possibility of a vessel collision:

- A support vessel will be present at all times in close proximity to the seismic vessel, with the potential for a chase vessel to also be utilised;
- All vessels involved with the survey will adhere to the COLREGS; and
- Other marine users will be notified of the seismic survey.

As a result, the risk of a vessel collision or sinking incident is considered to be.

6.4 Environmental Risk Assessment Summary

A summary of the ERA results is presented in **Table 27**.

Table 27 Summary of ERA Results for the 18SBB3D Seismic Survey

Effects from Planned Activities	**Significance of Residual Effects**
Presence of seismic vessel and towed equipment – marine mammal effects	Minor
Presence of seismic vessel and towed equipment – seabird effects	Negligible
Presence of seismic vessel and towed equipment – effects on other marine users	Minor
Acoustic disturbance – physiological effects on marine mammals (detected Species of Concern)	Moderate
Acoustic disturbance – physiological effects on marine mammals (undetected Species of Concern)	Major/Severe*
Acoustic disturbance – physiological effects on marine mammals (Other Marine Mammals)	Major/Severe*
Acoustic disturbance – physiological effects on seabirds	Minor
Acoustic disturbance – physiological effects on marine reptiles	Negligible
Acoustic disturbance – physiological effects on fish	Minor
Acoustic disturbance – physiological effects on cephalopods	Minor
Acoustic disturbance – physiological effects on benthic invertebrates	Minor
Acoustic disturbance – physiological effects on plankton	Moderate
Acoustic disturbance – behavioural effects on marine mammals	Moderate
Acoustic disturbance – behavioural effects on seabirds	Minor
Acoustic disturbance – behavioural effects on marine reptiles	Negligible
Acoustic disturbance – behavioural effects on fish and fisheries	Minor
Acoustic disturbance – behavioural effects on cephalopods	Minor
Acoustic disturbance – behavioural effects on benthic invertebrates	Minor
Acoustic disturbance – perceptual effects on marine mammals	Moderate
Acoustic disturbance – perceptual effects on fish	Moderate
Acoustic disturbance – indirect effects on marine mammals	Moderate
Effects from the discharge of biodegradable waste	Negligible
Effects from the discharge of non-biodegradable waste	Negligible
Effects from atmospheric emissions	Minor
Cumulative effects	Moderate
Effects from Unplanned Events	**Significance of Residual Effects**
Effects from invasive marine species	Negligible
Effects from streamer loss	Minor
Effects from hydrocarbon spills during refuelling	Minor
Effects from hydrocarbon spills during fuel tank rupture	Moderate
Effects from vessel collision or sinking	Moderate
Key * *Depending on approach distance to acoustic source*	

7 ENVIRONMENTAL MANAGEMENT PLAN

The protocols outlined in the MMMP (**Appendix C**) are the primary measures by which TEMS propose to manage environmental risks during the 18SBB3D seismic survey. The MMMP is the operating procedure that is followed by MMOs and the seismic vessel crew while at sea in order to ensure compliance with the Code of Conduct. Some additional measures over and above the requirements of the Code of Conduct will also be in place during the proposed operations. As well as being reflected in the MMMP, these measures are summarised in the Environmental Management Plan (EMP) presented in **Table 28**.

7.1 Research opportunities

The Code of Conduct states that during marine seismic surveys, research opportunities relevant to the local species, habitats and conditions should be undertaken where possible in order to increase the understanding of the effects of seismic surveys on the marine environment (DOC, 2013). The primary way in which the 18SBB3D seismic survey will contribute to research is through the submission of marine mammal data to DOC. These data are incorporated into the national marine mammal sighting database and is then accessible to third parties for research purposes on request.

In accordance with the Code of Conduct, and within 60 days following the completion of the survey, a Marine Mammal Observer Report is to be submitted. This report includes all marine mammal observation data collected, including when shut downs occurred on account of marine mammal detections. All raw datasheets must also be submitted directly to DOC at the earliest opportunity, but no longer than 14 days after the completion of each deployment.

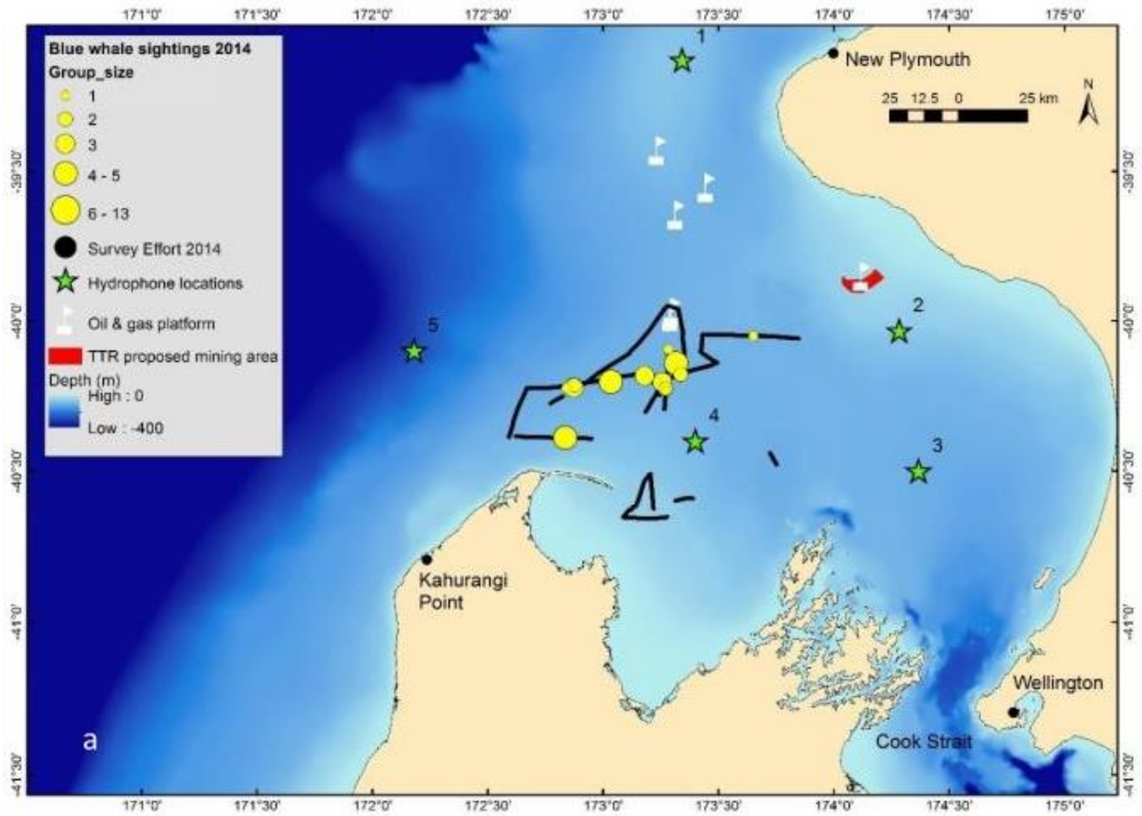
Due to public concerns about possible links between marine mammal strandings and seismic operations, strandings in the vicinity of a seismic survey are often targeted for necropsy to investigate links between seismic operations and acoustic injury. During any stranding event, DOC is responsible for all aspects of stranding management: including whether or not a necropsy will be undertaken to investigate the cause of death. TEMS will consider covering the costs associated with a necropsy if a dead marine mammal is found inshore of the Operational Area during acquisition and within two weeks of the end of the SouthTaranaki 3D Seismic Survey. Any resultant necropsy data would also be of benefit to the research community and data would be incorporated into the DOC stranding database.

With regard to other marine mammal research in the vicinity of the Operational Area, the following projects should be noted:

- DOC has hydrophones (CPODs) deployed in shallow water at Whanganui, Patea Project Reef, Bell Block, and Tongaporutu (C. Lilley, pers. comm.). These deployments are part of a project aimed at collecting additional acoustic data to determine the southern alongshore range of Maui’s dolphins. The 18SBB3D seismic survey will occur in close proximity to the Patea Project Reef hydrophones; and
- Since 2012 Oregon State University has been conducting summer surveys for blue whales in the South Taranaki Bight. While no boat survey is occurring this coming summer, hydrophones are currently deployed and will remain in-situ at the locations illustrated in **Figure 31** until January or February 2018 (at which time they will be retrieved) (L. Torres pers. comm.). The 18SBB3D seismic survey will occur in close proximity to hydrophone 2.

Both institutes involved in the research activities listed above have been contacted during the engagement process and are aware of the proposed 18SBB3D seismic survey.

Figure 31 Oregon State University Hydrophone Locations (green stars)



Source: Torres et al., 2017

Table 28 18SBB3D Seismic Survey Environmental Management Plan

Environmental Objectives	Proposed Controls	Relevant Legislation or Procedure
Minimise physiological, behavioural and perceptual effects to marine fauna	• The limited duration of operational activities serves to reduce the temporal scale of impacts to an anticipated five days • Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey • The slow speed (4-5 knots) of the seismic vessel will reduce the potential for collisions with marine fauna • Timing of the survey (summer months) is not predicted to affect whale migration behaviours • Source modelling has been undertaken to ensure that their survey is using the lowest possible acoustic source volume • Compliance with the Code of Conduct, including: ➢ Approved MMMP including visual and acoustic detections for delayed starts and shut-downs ➢ STLM has been conducted to tailor mitigation zones for this survey; and ground-truthing will occur ➢ PAM equipment is suitable for high frequency NZ Species of Concern • Marine mammal sightings will be collected whilst in transit to the Operational Area • MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea • MMOs to notify DOC immediately of any Hector's/Maui's dolphin sightings • Weekly MMO reports to be provided to DOC and EPA • Consideration to covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings	Code of Conduct EEZ Act 2012 MMMP Marine Mammals Protection Act 1978
Minimise disruption to other marine users	• The limited duration of operational activities serves to reduce the temporal scale of impacts to an anticipated five days • Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey • Comply with the COLREGS and have a support vessel present at all times • Notify commercial fishers of the proposed survey and provide 48 hr lookahed documents every 24 hours • Issue a Notice to Mariners and a coastal navigation warning • Display a tail buoy at the end of the streamer to mark the overall extent of the towed equipment	COLREGS International best practice
Minimise potential of invasive species	• Adherence to Craft Risk Management Standard for Vessel Biofouling (CRMS) • Adherence to Import Health Standard for Ships Ballast Water (IHS)	Biosecurity Act 1993 IHS CRMS
Minimise effects on water quality	• All discharges to sea will occur in accordance with MARPOL and relevant NZ legislation • On-board sewage treatment plant and approved ISPPC as applicable • On-board bilge water treatment plant to ensure oily water discharge does not exceed 15 ppm • All non-biodegradable waste to be returned to shore for disposed at an approved shore reception facility • A waste disposal log will be maintained on all survey vessels	MARPOL Annex V and IV Maritime Transport Act 1994 Marine Protection Rules Part 170 EEZ Discharge & Dumping Regulations 2015 Resource Management (Mar Pol) Regulations 1998
Minimise effects on air quality	• Regular maintenance of machinery • Approved IAPPC where applicable to vessel class and regular monitoring of fuel consumption	International best practice
Minimise the likelihood of unplanned events	• Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey • Comply with the COLREGS and have a support vessel present at all times • Approved SOPEP and IOPPC where applicable to vessel class • Refuelling at sea will only occur during daylight and in good sea conditions, and will be constantly monitored • Transfer hoses will be fitted with 'dry-break' couplings • Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas • Radio communications will be maintained between the seismic vessel and support vessel during refuelling • Solid streamers used in conjunction with self-recovery devices	International best practice COLREGS Maritime Protection Rules Part 130A and 123A JHA for refuelling
Minimise effects on cultural and socio-economic values	• Iwi MMOs and PAM operators will be provided with employment opportunities during the survey • Post-survey engagement will be conducted to inform interest groups of survey outcomes • Communication with commercial fishers will be maintained throughout the survey	Commitments during engagement

8 CONCLUSION

Marine seismic surveys are considered to be routine activities within the oil and gas industry and are a prerequisite for the discovery of hydrocarbons beneath the seabed. This MMIA identifies the potential environmental effects from the 18SBB3D seismic survey and describes all proposed mitigation measures that will be implemented to ensure that any potential effects are reduced to levels as low as reasonably practicable. Although the MMIA focusses largely on potential marine mammal effects, possible effects on other components of the marine ecosystem (e.g. seabirds, marine reptiles, fish, benthic invertebrates and plankton) are considered; as are the possible effects on socio-economic and cultural environments. The significance of any identified effect has been assessed using well-established ERA methodologies.

During the proposed 18SBB3D seismic survey, TEMS will comply with the Code of Conduct as the primary means of mitigating its environmental effects. In particular, there will be two MMOs and two PAM operators on-board the seismic vessel at all times. MMOs will conduct visual observations for marine mammals through daylight hours when the source is active and PAM operators will work around the clock to acoustically detect marine mammals at night and during poor sighting conditions. Depending on the circumstance and in keeping with the Code of Conduct requirements, marine mammal detections will trigger delayed starts or shut downs of the acoustic source as necessary. By committing to 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. As part of this compliance, STLM has been conducted and the results have been utilised to tailor mitigation zones (larger than those typically required) to ensure that marine mammals are sufficiently protected from physiological and behavioural effects during the 18SBB3D seismic survey.

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

In summary, the predicted effects of the 18SBB3D seismic survey are generally considered to be, with moderate effects representing a impact that is sufficiently managed by the proposed mitigation measures and the short duration of the survey.

Based on the potential for three consecutive surveys to be acquired in offshore Taranaki over the 2017/2018 summer seismic season there is a risk of some cumulative effects on marine mammal behaviour and perception (i.e. masking) across the wider South Taranaki Bight. The short duration (five days) of the 18SBB3D seismic survey is considered to make a limited contribution to the cumulative effects of the preceding Western Platform 3D and the subsequent Maui 4D surveys, which combined equate to more than 3 months of seismic operations. It is also worth bearing in mind that at distances beyond 100 km in the South Taranaki Bight the SELs from this survey are likely to be about the same as, or marginally above, the ambient noise levels in the ocean.

9 REFERENCES

Aguilar de soto, N., Atkins, J., Howard, S., Williams, J., Johnson, M 2013. "*Anthropogenic noise causes body malformations and delays development in marine larvae*". Scientific Report 3.

American Cetacean Society, 2014. '*Fact Sheet - Humpback whale'.* [Online]. Available: http://acsonline.org/fact-sheets/humpback-whale/

Anderson, O.F., Bagley, N.W., Hurst, R.J., Francis, M.P., Clark, M.R., McMillan, P.J., 1998. '*Atlas of New Zealand Fish and Squid Distributions From Research Bottom Trawls'*. NIWA Technical Report 42, pp. 300.

Anderson TJ, MacDiarmid A, Stewart R, 2013. '*Benthic habitats, macrobenthos and surficial sediments of the nearshore South Taranaki Bight*'. NIWA Client Report NEL2013-012.

Andre, M., Kamminga, C., 2000. '*Rhythmic Dimension In The Echolocation Click Trains Of Sperm Whales, A Possible Function Of Identification And Communication*'. Journal of the Marine Biological Association of the UK 80: 163-169.

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

Andriguetto-Filho, J. M., Ostrensky, A., Pie, M. R., Silva, U. A. and Boeger, W. A, 2005. '*Evaluating The Impact Of Seismic Prospecting On Artisanal Shrimp Fisheries'*. Continental Shelf Research, 25: 1720-1727.

Aroyan, J. L., McDonald, M. A., Webb, S. C., Hildebrand, J. A., Clark, D., Laitman, J. T, Reidneberg, J. S., 2000. '*Acoustic Models Of Sound Production And Propagation'*. In: Hearing by Whales and Dolphins, Ed: W. W. L. Au, A. N. Popper & R. N. Fay", 409-469 p. Springer, New York, U.S.

Asher, R, 2014, '*Statement of Evidence of Rod Asher for OMV New Zealand Limited – Benthic Ecology'*, 17 September, 2014, accessed from http://www.epa.govt.nz/EEZ/EEZ000007/EEZ000007_AppExWitness08_Asher_Rod_BenthicEcology.pdf.

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

Bagley, N.W., Anderson, O.F., Hurst, R.J., Francis, M.P., Taylor, P.R., Clark, M.R., Paul, L.J., 2000. '*Atlas of New Zealand Fish and Squid Distributions From Midwater Trawls, Tuna Longline Sets, and Aerial Sightings*'. NIWA Technical Report No: 72, pp. 167.

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

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

Baker, A.N., Madon, B, 2007. '*Bryde's Whales (Balaenoptera Cf. Brydei olsen 1913) In The Hauraki Gulf And Northeastern New Zealand Waters*'. Science for Conservation 272. Department of Conservation, Wellington, New Zealand. 23 p.

Baker, C. S., Chilvers, B. L., Constantine, R., DuFresne, S., Mattlin, R. H., van Helden, A., Hitchmough, R., 2010. '*Conservation Status Of New Zealand Marine Mammals (Suborders Cetacea And Pinnipedia) 2009*'. New Zealand Journal of Marine and Freshwater Research 44: 101–115.

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

Baker, C.S., Steel, D., Hamner, R., Hickman, G., Boren, L., Arlidge, W. & Constantine, R., 2016a. '*Estimating the abundance and effective population size of Maui dolphins using microsatellilte genotypes in 2015-16, with retrospective matching to 2001-16'*. Department of Conservation, Auckland. 74 pp.

Baker, A. N 1999, "*Whales and dolphins of New Zealand & Australia*", Victoria University Press, Wellington, New Zealand.

Ban, N., Alidina, H. & Ardron, J. 2010. Cumulative impact mapping: advances, relevance and limitations to marine management and conservation, using Canada's Pacific waters as a case study. Marine Policy 34: 876-886.

Barrett-Lennard, L., Ford, J., Heise, K 1996. "*The mixed blessing of echolocation: differences in sonar use by fisheating and mammal-eating killer whales*". Animal Behaviour 51: 553–565.

Bass, A.H., Ladich F., 2008. '*Vocal-Acoustic Communication: From Neurons To Behavior'*. In: Webb JF, Fay RR, Popper AN, editors. Springer handbook of auditory research. Vol. 32. New York: Springer. p. 253–278.

Battershill, C., 2016. 'Preparing For Oil And Gas Industry Expansion: 3D Seismic Campaigns And Coastal Resource Mapping In Northwest Australia – Warm And Cold Water Coral Habitat Responses'. Conference Abstract. New Zealand Petroleum Conference 20-22 March 2016. Auckland, New Zealand.

Bax, N., Williamson, A., Aguero, M., Gonzalez, E., Geeves, W., 2003. '*Marine Invasive Alien Species: A Threat To Global Biodiversity'*. Marine Policy, 27: 313 – 323.

Beatson, E., O'Shea, S., Ogle, M 2007. "*First report on the stomach contents of long-finned pilot whales, Globicephala melas, stranded in New Zealand*". New Zealand Journal of Zoology 34: 51−56.

Beaumont, J., Anderson, T. & MacDiarmid, A. 2015. "*Benthic flora and fauna of the Patea Shoals region, South Taranaki Bight*". Report prepared for Trans-Tasman Resources Ltd by NIWA. October 2013 (updated November 2015). NIWA Client Report No WLG2012-55

Bendell, A 2011. "*Shafag Asiman Offshore Block 3D Seismic Survey Exploration Survey – Environmental Impact Assessment*". Prepared for BP Azerbaijan, 23 August 2011. Reference No. P140167.

Benoit-Bird, K., Biggs, D., Engelhaupt, D., Gordon, J., Hu, C., Jaquet, N., Jochens, A., Johnson, M., Leben, R., Mate, B., Miller, P., Ortega-Ortiz, J., Thode, A., Tyack, P., Wormuth, J., Wursig, B., 2008. 'Sperm Whale Seismic Study In The Gulf Of Mexico: Synthesis Report'. Report prepared by Texas A&M University. Access Number 85186.

Berkenbusch, K., Abraham, E.R., Torres, L.G 2013, "*New Zealand marine mammals and commercial fisheries*", New Zealand Aquatic Environment and Biodiversity Report No. 119. Ministry for Primary Industries, Wellington, New Zealand. 113 p.

Black, A 2005. "*Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures*". Antarctic Science 17: 67-68.

Blackwell, S.B., Nations, C.S., McDonald, T.L., Thode, A.M., Mathias, D., Kim, K.H., Greene, C.R., Macrander, A.M., 2015. '*Effects Of Airgun Sounds On Bowhead Whale Calling Rates: Evidence Of Two Behavioural Thresholds'*. PLoS ONE 10(6): e0125720.

Boeger, W., Pei, M., Ostrensky, A., Cardaso, M 2006. "*The effect of exposure to seismic prospecting on coral reef fishes*". Brazilian Journal of Oceanography, 54: 235-239.

Boren, L 2005. '*New Zealand fur seals in the Kaikoura region: colony dynamics, maternal investment and health'*. PhD Thesis, University of Canterbury.

Bradford-Grieve, J., Stevens, C., 2015. 'Zooplankton and the Processes Supporting them in Greater Western Cook Strait'. Prepared for Trans-Tasman Resources Ltd, updated November 2015, NIWA Client Report No: WLG2013-9, 20pp

Bradford-Grieve, J., Murdoch, R., and Chapman, B., 1993. "*Composition of macrozooplankton assemblages associated with the formation and decay of pulses within an upwelling plume in greater Cook Strait, New Zealand*". New Zealand Journal of Marine and Freshwater Research, 27: 1 – 22.

Braham, H., Rice, D 1984. "*The right whale, Balaena glacialis*". Marine Fisheries Review.

Brodie, J. W 1960. "*Coastal surface currents around New Zealan*d". New Zealand Journal of Geology and Geophysics, 3: 235-252.

Brough, T.E., Guerra, M., Dawson, S.M. 2015. Photo-identification Of Bottlenose Dolphins In The Far South Of New Zealand Indicates A 'New' Previously Unstudied Population. New Zealand Journal of Marine and Freshwater Research, 49(1): 150 – 158.

Burtenshaw, J. C., Olesona, E. R., Hildebranda, J. A., McDonald, M. A., Andrew, R. K., Howe, M. B., Mercer, J. A 2004, "*Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific*", Deep Sea Research Part II: Topical Studies in Oceanography 51: 967.

Buscaino, G., Filiciotto, F., Buffa, G., Bellante, A., Di Stefano, V., Assenza, A., Fazio, F., Caola, G., Mazzola, S 2010. "*Impact of an acoustic stimulus on the motility and blood parameters of European sea bass (Dicentrarchus labrax L.) and gilthead sea bream (Sparus aurata L.)*". Marine Environmental Research 69: 136-142.

Cairns, D., 1950. '*New Zealand Freshwater Eels*'. Tuatara, 3(2): 43 – 52.

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

Carroll, A.G., Przeslawski, R., Duncan, A., Gunning, M., Bruce, B. 2017. A Critical Review Of The Potential Impacts Of Marine Seismic Surveys On Fish & Invertebrates. Marine Pollution Bulletin, 114: 9 – 24.

Carroll, E., Patenaude, N., Alexander, A., Steel, D., Harcourt, R., Childerhouse, S., Smith, S., Bannister, J., Constantine, R., Baker, C.S 2011, "*Population structure and individual movement of southern right whales around New Zealand and Australia*". Marine Ecology Progress Series 432: 257 – 268.

Cawthorn, M. 2013. Cetacean Monitoring Report. Report prepared for Trans Tasman Resources by Martin Cawthorn Associates Ltd. October 2013.

Chappell, P.R., 2014. '*The Climate and Weather of Taranaki'*. NIWA Science and Technology Series Number 64, p.40.

Christian, J.R., Mathieu, A., Buchanan, R.A. 2004. Chronic Effects of Seismic Energy on Snow Crab (Chionoecetes opilio). Environmental Funds Project No. 158. Fisheries and Oceans Canada. Calgary (25pp).

Clark, C., Ellison, W., Southall, B., Hatch, L., van Parijs, S., Frankel, A., Ponikaris, D., 2009. 'Acoustic Masking In Marine Ecosystems: Intuitions, Analysis And Implication'. Marine Ecology Progress Series 395: 201-222.

Colman, J. G., Grebe, C. C., Hearn, R. L 2008. "*The challenges and complexities of impact assessment for a seismic survey in a remote coral reef environment*".

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

Constantine, R., Baker, C 1997. "*Monitoring the commercial swim-with-dolphin operations in the Bay of Islands*". DOC, Wellington, New Zealand.

Constantine, R., Aguilar Soto, N., Johnson, M 2012, "*Sharing the waters: minimising ship collisions with Bryde's whales in the Hauraki Gulf*". Research Progress Report. February 2012. 22 p.

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

Croll, D. A., Marinovic, B., Benson, S., Chavez, F. P., Black, N., Ternullo, R., Tershy, B. R 2005, "*From wind to whales: trophic links in a coastal upwelling system*", Marine Ecology Progress Series 289: 117-130.

Cummings, W. C., Thompson, P. O 1971. "*Underwater sounds from the blue whale, Balaenopetera musculus*". Journal of the Acoustical Society of America 50: 1193-1198.

Curious Minds. 2017. South Taranaki Reef Life Project. https://www.curiousminds.nz/projects/south-taranaki-reef-life/

Currey, R.J.C., Boren, L.J., Sharp, B.J., Peterson, D 2012. "*A risk assessment of threats to Maui's dolphins*", Ministry for Primary Industries and Department of Conservation. Wellington. 51 p.

Dalebout, M. L., Robertson, K. M., Frantzis, A., Engelhaupt, D., Mignucci-Giannoni, A. A., Rosario-Delestre, R. J. and Baker, C. S., 2005. '*Worldwide structure of mtDNA diversity among Cuvier's beaked whales (Ziphius cavirostris): Implications for threatened populations*'. Molecular Ecology, 14: 3353-3371.

Dalen, J. 1994. '*Impact of seismic impulsive energy on marine organisms'*. Offshore oil activities and fisheries interactions workshop, Swakopmund, Nambia, 8-9 February 1994. Pages 60-75.

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

Dawbin, W. H. 1956. The migration of humpback whales as they pass the New Zealand coast. Transactions of the Royal Society of New Zealand 84:147–196.

Day, R.d., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M. 2016 '*Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries'*. Report to the Fisheries Research and Development Corporation. Report prepared by the University of Tasmania, Hobart.

De Ruiter, S., Doukara, K., 2012. '*Loggerhead Turtles Dive In Response To Airgun Sound Exposure'*. Endangered Species Research, 16: 55-63.

Deecke, V.B., Ford, J.K.B., Spong, P 2000, "*Dialect change in resident killer whales: implications for vocal learning and cultural transmission*", Animal Behaviour 60: 629 – 638.

Deepwater Group, 2017. Squid (SQU). http://deepwatergroup.org/species/squid/

Department of Justice. 2017. https://www.justice.govt.nz/maori-land-treaty/marine-and-coastal-area/applications/

Derraik, J.G.B., 2002. '*The Pollution of the Marine Environment by Plastic Debris: A Review*'. Marine Pollution Bulletin, 44: 842 – 852.

Di Iorio, L., Clark, C 2009. "*Exposure to seismic survey alters blue whale acoustic communication*". Biological Letters 6: 51-54.

Dilley, Capt. J.V., 2016. 'Port of Whanganui: Navigation Safety and Operational Review'. http://www.whanganui.govt.nz/our-district/major-projects/Port_Revitalisation/Ferryfeasibility/Documents/Whanganui%20Port%20Navigation%20and%20Operation%20Review%20Final%20-%20Oct-2016_Redacted%20(003).pdf

DIR, 2007. Petroleum Guidelines – Minimising Acoustic Disturbance to Marine Fauna. Department of Industry and Resources. Environment Division.

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

DOC, 2013. '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*'. In Department of conservation (DOC) (Ed.) Wellington, New Zealand: Department of Conservation.

DOC, 2014. '*Te Korowai o Te Tai ō Marokura Kaikoura Marine Management Area*'. http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-protected-areas/te-korowai-brochure.pdf

DOC 2015 "*DOC's work with southern right whales*", [Online]. Available: http://www.doc.govt.nz/conservation/native-animals/marine-mammals/whales/southern-right-whales-tohora/docs-work/

DOC, 2017. '*Hector's and Maui's Dolphin Incident Database*'. http://www.doc.govt.nz/our-work/hectors-and-maui-dolphin-incident-database/

DOC, 2017. '*Sea and Shore Birds'.* http://www.doc.govt.nz/nature/native-animals/birds/sea-and-shore-birds/

DOC, 2017. '*Sea Turtles*'. http://www.doc.govt.nz/nature/native-animals/marine-fish-and-reptiles/sea-turtles/

DOC, 2017. '*Sea Snakes and Kraits*'. http://www.doc.govt.nz/nature/native-animals/marine-fish-and-reptiles/sea-snakes-and-kraits/

DOC, 2017. '*Atlas of the Amphibian and Reptiles of New Zealand'. http://www.doc.govt.nz/our-work/reptiles-and-frogs-distribution/atlas/*

DOC, 2017. '*Eels*'. http://www.doc.govt.nz/nature/native-animals/freshwater-fish/eels/

DOC, 2017. '*Marine*'. http://www.doc.govt.nz/nature/habitats/marine/

DOC, 2017. *'West Coast North Island Marine Mammal Sanctuary'*. http://www.doc.govt.nz/nature/habitats/marine/other-marine-protection/west-coast-north-island/

DOC, 2017. '*Maui and/or Hector's dolphin sightings data – North Island, 1970 – January 2017'*. http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/mauis/maui-sightings-map-1970-to-current.pdf

Dodd, A, 2012. 'Taranaki Region Coastal Plan review: ARCHAELOGICAL SCOPING STUDY' Subsurface LTD. 62 pages.

DOSITS, 2017. 'Discovery of Sound in the Sea'. http://www.dosits.org/tutorials/sciencetutorial/speed/

Du Fresne, S 2010, "*Distribution of Maui's dolphin (Cephalorhynchus hectori maui) 2000-2009*", DOC Research & Development Series 322.

Duncan, A., 2016. '*Estimating Received Sound Levels At The Seafloor Beneath Seismic Survey Sources'*. Proceedings of 'Acoustics 2016', Conference, 9-11 November 2016. Brisbane, Australia.

Emama-Khoyi, A., Paterson, A., Hartley, D., Boren, L., Cruickshank, R., Ross, J., Murphy, E. & Else, T. 2017. '*Mitogenomics data reveal effective population size, historical bottlenecks, and the effects of hunting on New Zealand fur seals (Arctocephalus forsteri*)'. Mitochondrial DNA Part A, 2017. DOI: 10.1080/24701394.2017.1325478.

Engas, A., Lokkeborg, S., Ona, E., Soldal, A 1996. "*Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus)*". Canadian Journal of Fisheries and Aquatic Sciences, 53: 2238-2249.

Evans, K., Hindell, M.A 2004, "*The diet of sperm whales (Physeter macrocephalus) in southern Australian waters*", Journal of Marine Science 61: 1313 – 1329.

Fahlman, A., Tyack, P., Miller, P. & Kvadsheim, P. 2014. "*How man-made interference might cause gas bubble emboli in deep diving whales*". Fronteirs in Physiology 5: article 13; doi: 10.3389/fphys.2014.00013.

Fewtrell, J., McCauley, R 2012. "*Impact of air gun noise on the behaviour of marine fish and squid*". Marine Pollution Bulletin, 64; 984-993.

Fiedler, P. C., Reilly, S. B., Hewitt, R. P., Demer, D. A., Philbrick, V. A., Smith, S., Armstrong, W., Croll, D. A., Tershy, B. R., Mate, B. R 1998. "*Blue whale habitat and prey in the California Channel Islands*", Deep Sea Research Part II: Topical Studies in Oceanography, 45.

Fine, M.L., Thorson, R.F., 2008. '*Use Of Passive Acoustics For Assessing Behavioral Interactions In Individual Toadfish*'. Trans Am Fish Soc. 137:627–637.

Fletcher, L.M., Zaiko, A., Atalah, J., Richter, I., Dufour, C.M., Pochon, X., Wood, S.A., Hokpins, G.A., 2017. '*Bilge Water as a Vector for the Spread of Marine Pests: A Morphological, Metabarcoding and Experimental Assessment'*. Biological Invasions, DOI 10.1007/s10530-017-1489-y.

Forest and Bird, 2014. '*New Zealand Seabirds: Important Bird Areas and Conservation'*. The Royal Forest and Bird Protection Society of New Zealand, Wellington, New Zealand, pp. 72.

Forest and Bird, 2014a. '*New Zealand Seabirds: Sites at Sea, Seaward Extensions, Pelagic Areas'*. The Royal Forest and Bird Protection Society of New Zealand, Wellington, New Zealand, pp.91.

Forest and Bird, 2016. '*New Zealand Seabirds: Sites on Land, Rivers, Estuaries, Coastal Lagoons and Harbours'.* The Royal Forest and Bird Protection Society of New Zealand, Wellington, New Zealand, pp. 177.

Freeman et al. 2010. "*Conservation status of New Zealand marine invertebrates, 2009*". New Zealand Journal of Marine and Freshwater Research, 44: 3, 129 — 148

Gaskin, D.E., Cawthorn, M.W 1967, "*Diet and feeding habit of the sperm whale (Physeter catodon) in the Cook Strait region of New Zealand*", New Zealand Journal of Marine and Freshwater Research 2: 156–179.

Gibbs, N., Childerhouse, S 2000, "*Humpback whales around New Zealand*", Conservation Advisory Science Notes No. 257. Department of Conservation, Wellington, New Zealand. 27 p.

Gibbs, N., Dunlop, R., Gibbs, J., Heberley, J. & Olavarria, C. 2017. The potential beginning of a post-whaling recovery in New Zealand humpback whales (Megaptera novaeangliae). Marine Mammal Science, Online 5 December 2017, DOI: 10.1111/mms.12468

Gill, P. C., Morrice, M. G., Page, B., Pirzl, R., Levings, A. H., Coyne, M 2011, "*Blue whale habitat selection and within-season distribution in a regional upwelling system off southern Australia*", Marine Ecology Progress Series 421: 243-263.

Godoy, D.A., Smith, A.N.H., Limpus, C., Stockin, K.A., 2016. '*The Spatio-temporal Distribution and Population Structure of Green Turtles (Chelonia mydas) in New Zealand'*. New Zealand Journal of Marine and Freshwater Research, 50(4): pp.18.

Goetz, K., 2017. '*Unique Research Records Rare Whale Species In Cook Strait'*. NIWA media release 29 March 2017. https://www.niwa.co.nz/news/unique-research-records-rare-whale-species-in-cook-strait

Gomez-Villota, F 2007."*Sperm whale diet in New Zealand*". Unpublished MAppSc thesis. Division of Applied Sciences, Auckland University of Technology, Auckland, New Zealand. 221 p.

Goodman, J.M., Dunn, N.R., Ravenscroft, P.J., Allibone, R.M., Boudee, J.A.T., David, B.O., Griffiths, M., Ling, N., Hitchmough, R.A., Rolfe, J.R., 2013. '*Conservation Status of New Zealand Freshwater Fish, 2013'*. Department of Conservation, Wellington, pp. 16.

Goold, J 1996. "*Acoustic assessment of populations of common dolphin Delphinus delphis in conjunction with seismic surveying*". Journal of the Marine Biological Association of the UK, 76: 811-820.

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

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

Goudie, R.I., Ankney, C.D., 1986. '*Body Size, Activity Budgets, And Diets Of Sea Ducks Wintering In Newfoundland'*. Ecology, 67: 1475–1482.

Hadfield, M. & Macdonald, H. 2015. Sediment plume modelling. Report prepared for Trans-Tasman Resources, October 2015 by NIWA. Client Report No: WLG2015-22

Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S., Wilson, B 2008 "*Delphinus delphis*. The IUCN Red List of Threatened Species. Version 2014.2", <www.iucnredlist.org>. Downloaded on 11 September 2015.

Hamner, R.M., Oremus, M., Stanley, M., Brown, P., Constantine, R., Baker, C.S 2012. "*Estimating the abundance and effective population size of Maui's dolphins using microsatellite genotypes in 2010–11, with retrospective matching to 2001–07*", Department of Conservation, Auckland. 44 p.

Hamner, R.M., Constantine, R., Oremus, M., Stanley, M., Brown, P., Baker, C.S., 2013. ‘Long-Range Movement By Hector’s Dolphins Provides Potential Genetic Enhancement For Critically Endangered Maui’s Dolphin’. Marine Mammal Science 30(1): 139 - 153.

Handegard, N., Tronstad, T., Hovem, J., Jech, J 2013. "*Evaluating the effect of seismic surveys on fish — the efficacy of different exposure metrics to explain disturbance*". Canadian Journal of Fisheries and Aquatic Sciences, 70: 1271-1277.

Handley, S, 2006, ‘*An Analysis of Historical Impacts and Composition of the Benthic Environment of Tasman and Golden Bays’*, NIWA Client Report: NEL2006 - 002.

Harcourt, R., Bradshaw, C., Dickson, K., Davis, L 2002. "*Foraging ecology of a generalist predator, the female New Zealand fur sea*l". Marine Ecology Progress Series 227: 11–24.

Harrington, J.J., McAllister, J., Semmens, J.M. 2010. Assessing the Short-Term Impact of Seismic Surveys on Adult Commercial Scallops (*Pecten fumatus*) in Bass Strait. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Lokkeborg, S., Misund, O., Ostensen, O., Fonn, M., Haugland, E 2004. *"Influence of seismic shooting on the lesser sandeel (Ammodytes marinus)*". ICES Journal of Marine Science,61: 1165-1173

Heath, R. A 1985. "*A review of the physical oceanography of the seas around New Zealand — 1982*". New Zealand Journal of Marine and Freshwater Research, 19: 79-124.

Hickok, K. 2017. Whales and dolphins can naturally muffle loud sounds, potentially protecting them from sonar and other dangers. Science. 11 December 2017.

Horizons 2014. *Manawatu-Wanganui Regional Council One Plan*. Prepared by Horizons Regional Council. Report Number: 2014/EXT/1338.

Hume, T., Ovenden, R., MacDonald, I., 2015. ‘*Coastal Stability in the South Taranaki Bight – Phase 1. Historical and Present Day Shoreline Change’.* Prepared for Trans-Tasman Resources Ltd, NIWA Client Report No: HAM2012-083, pp.58.

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

Hurst, R.J., Bagley, N.W., Anderson, O.F., Francis, M.P., Griggs, L.H., Clark, M.R., Paul, L.J., Taylor, P.R., 2000. ‘Atlas of Juvenile and Adult Fish and Squid Distributions from Bottom and Midwater Trawls and Tuna Longlines in New Zealand Waters’. NIWA Technical Report 84, 162pp.

ISO, 2009. ‘*ISO 31000:2009, Risk Management Principles and Guidelines’*. Available online from http://www.iso.org/iso/catalogue_detail?csnumber=43170.

IUCN, 2017. http://www.iucnredlist.org/details/2474/0

IWC, 2007. ‘*Report of the Scientific Committee Annex K’*. Report of the Stranding Working Group on Environmental Concerns. Journal of Cetacean Research and Management Supplement 9: 227-296.

Jackson, J., Carroll, E., Smith, T., Zerbini, A., Patenaude, N. & Baker, C.S. 2016. ‘*An integrated approach to historical population assessment of the great whales: case of the New Zealand southern right whale*’. Royal Society Open Science 3: 150669. http://dx.doi.org/10.1098/rsos.150669.

Jakupsstovu, S., Olsen, D., Zachariassen, K 2001. *Effects of seismic activities on the fisheries at the Faroe Islands.*

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

Jefferson, T. A., Leatherwood, S., Webber, M. A., 1993.'*Marine Mammals of the World: FAO Species Identification Guide'*. United Nation Environment Programme and Food and Agricultural Organization of the UN.

Jefferson, T.A., Webber, M.A., Pitman, L 2008, "*Marine mammals of the world: a comprehensive guide to their identification*", Elsevier 573 p

Jellyman, D., 2012. '*The Status of Longfin Eels in New Zealand – An Overview of Stocks and Harvest'.* NIWA Client Report No: CHC2012-006, prepared for Parliamentary Commissioner for the Environment, pp. 78.

Jensen, A., Silber, G 2004. *Large Whale Ship Strike Database*. U.S. Department of Commerce. 37 pp

Johnson, M., Soto, N., Madsen, P 2009. "*Studying the behaviour and sensory ecology of marine mammals using acoustic recording tags: a review*". Marine Ecology Progress Series, 395: 55-73.

Johnston, O., 2016. '*Sensitive Habitats and Threatened Species in the Taranaki Coastal Marine Area (TCMA) – Database Investigation'*. Prepared for Taranaki Regional Council, Cawthron Report No. 2877, pp.28 plus appendices.

Kaifu, K., Segawa, S., Tsuchiya, K. 2007. Behavioral responses to underwater sound in the small benthic octopus Octopus ocellatus. J. Mar. Acoust. Soc. Jpn. 34, 266–27

Kato, H 2002. *Bryde's whales*. Pages 171–177 in W. F. Perrin, B. Wursig and J. G. M. Thewissen, eds. Encyclopaedia of marine mammals. Academic Press, San Diego, CA

Kemper, K. 2002. '*Distribution of the Pygmy Right Whale, Caperea marginata, in the Australasian Region'*, Marine Mammal Science 18(1): 99 - 111.

Kemper, C.FM., Middleton, J.F., van Ruth, P.D. 2013. '*Association between pygmy right whales (Capera marginata) and areas of high marine productivity off Australia and New Zealand'.* New Zealand Journal of Zoology. 40:2, 102-128

Ketten, D., 2005. '*Experimental Measures Of Blast Trauma In Sea Turtles'*. Symposium on Environmental Consequences of Underwater Sound, Office of Naval Research, Arlington, VA.

Kosheleva, V. 1992. '*The impact of airguns used in marine seismic exploration on organisms living in the Barents Sea*'. Fisheries and offshore petroleum exploration. 2nd International Conference, Bergen, Norway, 6-8 April.

Kyhn, LA., Tougaard, J., Jensen, F., Whalberg, M., Stone, G., Yoshinaga, A., Beedholm, K., Madsen, PT 2009*. Feeding at a high pitch: source parameters of narrow band, high-frequency clicks from echo-locating off-shore hourglass dolphins and coastal Hector's dolphins*. Journal of the Acoustical Society of America 125(3): 1783 – 1791.

Labella, A., Cannata, S., Froglia, C., Ratti, S., Rivas, G 1996. "*First assessment of effects of air-gun seismic shooting on marine resources in the central Adriatic Sea".* The Third international conference on health, safety & environment in oil & gas exploration & production: New Orleans LA, 9-12 June 1996 (pp. 227-238) New Orleans LA, US.

Lacroix, D., Lanctot, R., Reed, J., McDonald, T., 2003. '*Effects Of Underwater Seismic Surveys On Molting Male Long-Tailed Ducks In The Beaufort Sea, Alaska'*. Canadian Journal of Zoology 81: 1862-1875.

Ladich F., Collin S.P., Moller P., Kapoor B.G., 2006. '*Fish Communication'*. Enfield (CT): Science Publisher.

Lalas, C., Bradshaw, C 2001. "*Folklore and chimerical numbers: review of a millennium of interaction between fur seals and humans in the New Zealand region*". New Zealand Journal of Marine and Freshwater Research, 35: 477-497.

Lalas, C., McConnell, H. 2015. "*Effects of Seismic Surveys on New Zealand fur seals during daylight hours: do fur seals respond to obstacles rather than airgun noise?"* Marine Mammal Science. DOI 10.1111/mms.12293

Lavery, S., Hingston, M., Veale, A. and Hinnendael, F 2007. *Connectivity of invertebrate populations on coastal reefs: Implications for marine protected areas (MPA) design and research*. Progress Report Auckland: University of Auckland.

Lesage, V., Barrette, C., Kindgsley, M., Sjare, B 1999. "*The effect if vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada*". Marine Mammal Science, 15: 65-84.

Li, W.C., Tse, H.F., Fok, L., 2016. '*Plastic Waste in the Marine Environment: A Review of Sources, Occurrence and Effects'*. Science of the Total Environment, 566-567: 333 – 349.

Luczkovich, J.J., Daniel, H.J., Hutchinson, M., Jenkins, T., Johnson, S.E., Pullinger, R.C., Sprague, M.W., 2000. '*Sounds Of Sex And Death In The Sea: Bottlenose Dolphin Whistles Suppress Mating Choruses Of Silver Perch'*. Bioacoustics10:323–334.

Lugli, M., Yan, H.Y., Fine, M.L., 2003. '*Acoustic Communication In Two Freshwater Gobies: The Relationship Between Ambient Noise, Hearing Thresholds And Sound Spectrum'*. J Comp Phys A. 189:309–320.

MacDiarmid, A., Ballara, S., 2016. 'South Taranaki Bight Commercial Fisheries: 1 October 2006 – 30 September 2015'. Prepared for Trans-Tasman Resources Ltd, May 2016, NIWA Client Report No: WLG2016-28, 26pp.

MacDiarmid, A., Beaumont, J., Bostock, H., Bowden, D., Clark, M., Hadfield, M., Heath, P., Lamarche, G., Nodder, S., Orpin, A., Stevens, C., Thompson, D., Torres, L., Wysoczanski, R. 2012. '*Expert Risk Assessment of Activities in the New Zealand Exclusive Economic Zone and Extended Continental Shelf'*. Report prepared by NIWA for the Ministry for the Environment. Report No. WLG2011-39.

MacDiarmid, A., Bowden, D., Cummings, V., Morrison, M., Jones, E., Kelly, M., Neil, H., Nelson, W., Rowden, A., 2013. '*Sensitive Marine Benthic Habitats Defined'*. Prepared for Ministry for the Environment, NIWA Client Report No: WLG2013-18.

MacDiarmid, A., Anderson, O., Beaumont, J., Gorman, R., Hancock, N., Julian, K., Schwarz, J., Stevens, C., Sturman, J., Thompson, D., Torres, L., 2015. '*South Taranaki Bight Factual Baseline Environment Report*'. Prepared for Trans-Tasman Resources Ltd, NIWA Client Report: WLG2011-43.

MacDiarmid, A., Anderson, O., Sturman, J., 2015a. 'South Taranaki Bight Fish and Fisheries'. Prepared for Trans-Tasman Resources Ltd, Updated November 2015, NIWA Client Report No: WLG2012-13, 210pp.

MacDonald, I., Budd, R., Bremner, D & Edhouse, S. 2015. South Taranaki Bight Iron Sand Mining: Oceanographic measurements data report.

Macduff-Duncan, C., Davies, G 1995. "*Managing seismic exploration in a nearshore environmentally sensitive areas"*

Mackenzie, DL., Clement, DM 2014. '*Abundance and distribution of ECSI Hector's Dolphins'*. NZ Aquatic Environment and Biodiversity Report No. 123. Ministry for Primary Industries, Wellington, New Zealand

MacKenzie, D.I., Clement, D.M. 2016, '*Abundance and Distribution of WCSI Hector's Dolphins'*, New Zealand Aquatic Environment and Biodiversity Report No. 168, Ministry Primary Industries, Wellington, New Zealand.

MacKenzie, L 2014. '*Statement of Evidence of Lincoln MacKenzie for OMV New Zealand Limited – Primary Productivity, Plankton, Toxic Algae and Nutrient Pathways*', 17 September 2014.

MarineLife, 2017, http://www.marinelife.ac.nz/

Markowitz, T., Harlin, A.D., Würsig, B., McFadden, C.J 2004. "*Dusky dolphin foraging habitat: overlap with aquaculture in New Zealand*", Aquatic Conservation: Marine and Freshwater Ecosystems 14: 133–149.

Marten, K. 2000. '*Ultrasonic analysis of Pygmy Sperm Whale (Kogia breviceps) and Hubbs' Beaked Whale (Mesoplodon carhubbsi) Clicks'*. Aquatic Mammals 26(1): 45 – 48.

Matishov, G.G. 1992. '*The reaction of bottom fish larvae to airgun pulses in the context of the vulnerable Barents Sea ecosystem'*. Fisheries and offshore petroleum and exploitation. 2nd International Conference, Bergen, Norway 6-8 April 1992.

Matsuoka, K., Fujise, Y. and Pastene, L. A. 1996. '*A sighting of a large school or the pygmy right whale, Caperea marginata, in the southeast Indian Ocean'*, Marine Mammal Science 12(4): 594-596.

Mattlin, R., Gales, N., Costa, D 1998. "*Seasonal dive behaviour of lactating New Zealand fur seals (Arctocephalus forsteri)*". Canadian Journal of Zoology, 76(2): 350-360.

McCauley, R 1994. "*Seismic surveys*". In J. M. Swan, J. M. Neff and P. C Young Eds. Environmental implications of offshore oil and gas developments in Australia. The findings of an independent scientific review. Australian Petroleum Exploration Association, Sydney, NSW.

McCauley, R. D., Jenner, C., Jenner, M. N., Murdoch, J. and McCabe, K 1998. "*The response of humpback whales to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures*". APPEA Journal 2000: 692-708.

McCauley, R., Fewtrell, J., Duncan, A., Jenner, C., Jenner, M., Penrose, J., Prince, R., Adhitya, A., Murdoch, J., McCabe, K 2000. "*Marine Seismic Surveys – A Study of Environmental Implications*". APPEA Journal 2000.

McCauley, R., Fewtrell, J., Duncan, A., Jenner, C., Jenner, M., Penrose, J., Prince, R., Adhitya, A., Murdoch, J., McCabe, K 2000. "*Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals; and Effects of Air-gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid*". Report prepared for Australian Petroleum Production Exploration Association by Centre of Marne Science and Technology, Curtin University of Technology. August 2000.

McCauley, R., Fewtrell, J., Popper, A. 2003. "*High intensity anthropogenic sound damages fish ears"*. Journal of the acoustical society of America, 113: 1-5.

McCauley, R., Fewtrell, J., Duncan, A., Jenner, C., Jenner, M., Penrose, J. D, Prince, R., Adhitya, A., Murdoch, J., McCabe, K 2003a. "*Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals in Environmental implications of offshore oil and gas development in Australia: further research*". APPEA Ltd.

McCauley, R., Day, R., Swadling, K., Fitzgibbon, Q., Watson, R., Semmens, J., 2017. '*Widely Used Marine Seismic Survey Air Gun Operations Negatively Impact Zooplankton'*. Nature, Ecology & Evolution 1, 0195. DOI: 10.1038/s41559-017-0195.

McComb, P., Mead, S., & B. Beamsley. 2004. Summary of the existing oceanographic environement in the vicinity of the Kupe Development Project. Report No. 3. ASR Marine Consulting and Research.

McConnell, H, 2014. '*Statement of Evidence of Helen McConnell for OMV New Zealand Limited – Oiled Wildlife'*. Prepared for the OMV Maari Field Development Marine Consent Application, 17 September 2014, pp.48.

McDonald, M. A., Calambokidis, J., Teranishi, A. M., Hildebrand, J. A 2001, "*The acoustic calls of blue whales off California with gender data*", The Journal of the Acoustical Society of America 109: 1728-1735.

McGregor, PK., Horn, AG., Leonard, ML., Thomsen, F 2013. "*Anthropogenic noise and conservation*" In: Animal Communication and Noise, Animal Signals and Communication 2. (ed. H. Brumm) Springer Verlag Berlin, Germany

McMillan, P.J., Francis, M.P., James, G.D., Paul, L.J., Marriott, P.J., Mackay, E., Wood, B.A., Griggs, L.H., Sui, H., Wei, F., 2011. '*New Zealand Fishes. Volume 1: A Field Guide to Common Species Caught by Bottom and Midwater Fishing'*. New Zealand Aquatic Environment and Biodiversity Report No. 68, pp. 329.

McMillan, P.J., Griggs, L.H., Francis, M.P., Marriott, P.J., Paul, L.J., Mackay, E., Wood, B.A., Sui, H., Wei, F., 2011a. '*New Zealand Fishes. Volume 3: A Field Guide to Common Species Caught by Surface Fishing'*. New Zealand Aquatic Environment and Biodiversity Report No. 69, pp. 147.

Meynier, L., Stockin, K. A., Bando, M. K. H., Duignan, P. J 2008. "*Stomach contents of common dolphin (Delphinus sp.) from New Zealand waters*", New Zealand Journal of Marine and Freshwater Research 42: 257-268.

MFish, 2008, 'Species under consideration for introduction into the Quota Management System on 1 October 2009: information briefs and risk analyses', Report Prepared by the Ministry of Fisheries 10 June 2008. http://www.fish.govt.nz/NR/rdonlyres/2F8696DC-9AF4-45D0-B59C-0CAA97104E45/0/InformationbriefsandriskanalysesforspeciesunderconsiderationforQMSintroduction1October2009.pdf

Miller, B. S., Collins, K., Barlow, J., Calderan, S., Leaper, R., McDonald, M., Ensor, P., Olson, P., Olavarria, C., Double, M. C 2014, "*Blue whale songs recorded around South Island, New Zealand 1964-2013*", Journal of the Acoustical Society of America 135: 1616-1623.

Miyashita, T., Kato, H., Kasuya, T 1995. *Worldwide map of cetacean distribution based on Japanese sighting data*. Volume 1. National Research Institute of Far Seas Fisheries, Shizuoka, Japan. 140p.

Mooney, T.A., Kaplan, M.B., Lammers, M.O. 2016. '*Singing whales generate high levels of particle motion: implications for acoustic communication and hearing*?' Biol. Lett. 12: 20160381.

Moore, S.F., Dwyer, R.L., 1974. 'Effects of Oil on Marine Organisms: A Critical Assessment of Published Data'. Water Research, 8(10): 819 – 827.

Moriyasu, M., Allain, R., Benhalima, K., Clator, R 2004. *Effects of seismic and marine noise on invertebrates: A literature Review*. Fisheries and Oceans Canada.

Morrison, M.A., Jones, E.G., Parsons, D.P., Grant, C.M., 2014. '*Habitats and Areas of Particular Significance for Coastal Finfish Fisheries Management in New Zealand: A Review of Concepts and Life History Knowledge, and Suggestions for Future Research'*. New Zealand Aquatic Environment and Biodiversity Report No: 125, pp. 202.

Morton, J., Miller, M 1968. "*The New Zealand Sea Shore*". Collins, London - Auckland.

MPI 2015. *Arrow squid* [Online]. Available: http://fs.fish.govt.nz/Page.aspx?pk=8&stock=SQU1T

MPI, 2017. '*Fishery - Squid'. http://fs.fish.govt.nz/Page.aspx?pk=5&tk=1&fpid=48*

MPI, 2017a. '*Fishery – West Coast North Island Finfish'*.
http://fs.fish.govt.nz/Page.aspx?pk=5&fpid=14

MyWeather. 2017. http://www.myweather2.com/City-Town/New-Zealand/Wanganui/climate-profile.aspx?month=12

Nelms, S., Piniak, W., Weir, C., Godley, B., 2016. '*Seismic Surveys And Marine Turtles: An Underestimated Global Threat?*'. Biological Conservation 193: 49-65.

Neumann, DR. 2001. Seasonal movements of short-beaked common dolphins (Delphinus delphis) in the north-western Bay of Plenty, New Zealand: influence of sea surface temperature and El Nino/La Nina. Short Communication. New Zealand Journal of Marine and Freshwater Research 35: 371 – 374.

New Zealand Birds Online 2017. http://nzbirdsonline.org.nz/

Ngaa Rauru Kiitahi, 2003. 'Deed of Settlement of the Historical Claims of Ngaa Rauru Kiitahi', http://nz01.terabyte.co.nz/ots/DocumentLibrary%5CNgaaRauruDeed.pdf

Nga Ruahine, 2014, 'Deed of Settlement of Historical Claims',
http://nz01.terabyte.co.nz/ots/DocumentLibrary%5CNgaruahine-DeedofSettlement.pdf

Nga Uri O Tahinga Trust 2012, "*Tahinga Environmental Management Plan*"

Ngāti Ruanui. 2001, 'Deed of Settlement of Historical Claims', accessed from
http://nz01.terabyte.co.nz/ots/DocumentLibrary/RuanuiDeed12May2001.pdf

NIWA, 2017. '*Tuna – Spawning Grounds'*. https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/biology-and-ecology/spawning-grounds

Noad, M., Cato, D., Dunlop, R., McCauley, R. 2011. 'Measuring behavioural impacts of seismic surveys on humpback whales (*Megaptera novaeangliae*)'. Conference paper published in the Program and Abstracts for the 2011 meeting of the Australian Marine Sciences Association, Fremantle, Australia, 3-7 July, 2011.

Nodder, S 1995. "*Late quaternary transgressive/regressive sequences from Taranaki continental shelf, western New Zealand*". Marine Geology, 123: 187-214.

Nowacek, D., Thorne, L., Johnston, D., Tyack, P 2007. "*Responses of cetaceans to anthropogenic noise*". Mammal Review, 37: 81-115

NZGeo.com, 2016. '*The Humpback Highway*' https://www.nzgeo.com/stories/the-humpback-highway/

NZOG, 2017. '*Kupe*'. https://www.nzog.com/producing-assets/kupe/

NZP&M, 2013, '*New Zealand Petroleum Basin*s', http://www.nzpam.govt.nz/cms/about-nzpam/doc-library/factsheets/petroleum-basins-part2.pdf

NZP&M 2015. http://www.nzpam.govt.nz/cms/investors/doc-library/petroleum-basins/taranaki-basin-factsheet.pdf

O'Callaghan, T.M., Baker, A.N., Helden, A 2001, *"Long-finned pilot whale strandings in New Zealand – the past 25 years*", Science poster no. 52, Department of Conservation, Wellington, New Zealand. Available from http://www.doc.govt.nz/Documents/science-andtechnical/SciencePoster52.pdf.

O'Driscoll, R.L., Booth, J.D., Bagley, N.W., Anderson, O.F., Griggs, L.H., Stevenson, M.L., Francis, M.P. 2003. '*Areas of Importance for Spawning, Pupping, or Egg-laying and Juveniles of New Zealand Deepwater Fish, Pelagic Fish, and Invertebrates'*. NIWA Technical Report 119, 377p.

O'Shea, S. 2013, 'The Deep-sea Finned Octopoda of New Zealand', https://www.tonmo.com/pages/finned-octopoda/

Oil & Gas Journal, 2017. '*New Zealand Oil & Gas to Buy Back into Kupe Field'*. http://www.ogj.com/articles/2017/05/new-zealand-oil-gas-to-buy-back-into-kupe-field.html

Oleson, E., Barlow, J., Gordon, J., Rankin, S., Hildebrand, J., 2003. '*Low frequency calls of Bryde's whales'*. Marine Mammal Science, 19(2): 407-419.

Olson, P.A., Ensor, P., Olavarria, C., Schmitt, N., Childerhouse, S., Constantine, R., Miller, B.S., Double, M.C 2013. "*New Zealand blue whales: initial photo-identification of a little-known population*", Report to the Scientific Committee of the International Whaling Commission SC/65a/SH12.

Parks, S., Johnson, M., Nowacek, D., Tyack, P. L 2011. "*Individual right whales call louder in increased environmental noise*". Biology Letters 7: 33-35.

Parry, G.D. and Gason, A 2006. "*The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia*". Fisheries Research 79:272 – 284

Patenaude, N.J 2003, "*Sightings of southern right whales around 'mainland' New Zealand*", Science for Conservation 225, Department of Conservation, Wellington, New Zealand 15 p.

Payne, J 2004. *Potential effect of seismic surveys on fish eggs, larvae and zooplankton*. Canadian Science Advisory Secretariat Research Document: CSAS.

Payne, J.F., Andrews, C.A., Fancey, L.L., Cook, A.L., Christian, J.R., 2007. '*Pilot Study On The Effect Of Seismic Airgun Noise On Lobster (Homarus Americanus*)'. Can. Tech. Rep. Fish. Aquat. Sci 2712: v+46

Pearson, W., Skalski, J., Malme, C 1992. "*Effects of sounds from geophysical survey device on behavior of captive rockfish (Sebastes spp.)*". Canadian Journal of Fisheries and Aquatic Sciences, 49: 1343-1356.

Peña H., Handegard N.O., Ona E., 2013. '*Feeding Herring Schools Do Not React To Seismic Airgun Surveys'*. ICES Journal of Marine Science. doi: 10.1093/icesjms/fst079

Perić, T., 2016. '*Wastewater Pollution from Cruise Ships in Coastal Sea Area of the Republic of Croatia'*. Scientific Journal of Maritime Research, 30: 160 – 164.

Perrin, W.F 2009, "*Minke whales Balaenoptera acutorostrata and B. bonaerensis.* In, W. F. Perrin and B. Würsig and J. G. M. Thewissen (Ed.), Encyclopaedia of marine mammals", pp. 733–735. Academic Press, United States.

Petrella, V., Martinez, E., Anderson, M., Stockin, K 2012, "*Whistle characteristics of common dolphins (Delphinus sp.) in the Hauraki Gulf, New Zealand*", Marine Mammal Science 28: 479 - 496.

Picciulin, M., Sebastianutto, L., Codarin A., Calcagno, G., Ferrero, E.A., 2012. '*Brown Meagre Vocalization Rate Increases During Repetitive Boat Noise Exposures: A Possible Case Of Vocal Compensation*'. Journal of the Acoustical Society of America132:3118–3124.

Pichegru, L., Nyengera, R., McInnes, A. & Pistorius, P. 2017. Avoidance of seismic survey activities by penguins. Scientific Reports 7: 16305. DOI:10.1038/s41598-017-16569-x.

Pickett, G., Eaton, D., Seaby, R., Arnold, G 1994. *Results of bass tagging in Poole Bay during 1992*. Ministry of Agriculture Fisheries and Food.

Pitman, R. L., 2002. 'Mesoplodont whales Mesoplodon spp. In: W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), Encyclopedia of Marine Mammals;. pp. 738-742. Academic Press.

Popper, A., Hastings, M 2009. "*The effects of anthropogenic sources of sound on fishes*". Journal of Fish Biology, 75: 455-489.

Popper, A., Smith, M., Cott, P., Hanna, B., MacGillivray, A., Austin, M., Mann, D 2005. "*Effects of exposure to seismic airgun use on hearing of three fish species*". Journal of the acoustical society of America, 117: 3958-3971.

Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Lokkeborg, S., Rogers, P., Southall, S., Zeddies, D., Tavlga, W., 2014. '*Sound exposure guidelines for fishes and sea turtles'*. A technical report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Acoustical Society of America and Springer Press. 88 pp.

Poupart, T.A., Waugh, S.M., Bost, C., Bost, C-A., Dennis, T., Lane, R., Rogers, K., Sugishita, J., Taylor, G.A., Wilson, K-J., Zhang, J., Arnould, J.P.Y., 2017. '*Variability in the Foraging Range of Eudyptula minor Across Breeding Sites in Central New Zealand*'. New Zealand Journal of Zoology, 44(3): 225 – 244.

Radford, A., Kerridge, E., Simpson, S., 2014. '*Acoustic Communication In A Noisy World: Can Fish Compete With Anthropogenic Noise?'.* Behavioural Ecology 25(5): 1022-1030.

Rayment, W., Davidson, A., Dawson, S., Sloote*n, E., Webster, T 2012. "Distribution of southern right whales on the Auckland Island calving grounds*", New Zealand Journal of Marine and Freshwater Research 46: 431 – 436.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N 2008. *Balaenoptera bonaerensis*. The IUCN Red List of Threatened Species 2008: e.T2480A9449324. . Downloaded on 24 September 2015

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N 2008a. *Balaenoptera acutorostrata*. The IUCN Red List of Threatened Species 2008: e.T2474A9444043. . Downloaded on 24 September 2015.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N 2013. *Balaenoptera physalus*. The IUCN Red List of Threatened Species 2013: e.T2478A44210520. . Downloaded on 24 September 2015.

Rice, D 1978, "*Blue Whale*. In: Marine mammals of the Eastern Pacific and Antarctic Waters ed: D. Haley", Pacific Search Press.

Richardson, J., Greene, C., Malme, C., Thompson, D 1995. "*Marine Mammal and Noise*". Academic Press, San Diego, U.S.

Richardson A.J., Matear R.J., Lenton A., 2017. '*Potential impacts on zooplankton of seismic surveys*'. CSIRO, Australia. 34 pp.

Richter, C. F., Dawson, S.M., Slooten, E., 2003. '*Sperm Whale Watching off Kaikoura, New Zealand: Effects of Current Activities on Surfacing and Vocalisation Patterns'*. Science for Conservation Report No. 219. Department of Conservation, Wellington, New Zealand.

Ridgway, N. M 1980. *Hydrological conditions and circulation off the west coast of the North Island, New Zealand*. New Zealand Journal of Marine and Freshwater Research, 14, 155-167.

Riekkola, L 2013, "*Mitigating collisions between large vessels and Bryde's whales in the Hauraki Gulf, New Zealand*", A dissertation in partial fulfilment for the degree of Bachelor of Science with Honours. University of Auckland, New Zealand. 68 p.

Rob Greenaway & Associates, 2015. 'Trans-Tasman Resources Ltd Sea Bed Mining South Taranaki – Recreation and Tourism Assessment of Effects'. Prepared for Trans-Tasman Resources Ltd, November 2015, 45pp.

Robertson, H.A., Baird, K., Dowding, J.E., Elliott, G.P., Hitchmough, R.A., Miskelly, C.M., McArthur, N., O'Donnell, C.F.J., Sagar, P.M., Scofield, P., Taylor, G.A., 2016. '*Conservation Status of New Zealand Birds, 2016'*. New Zealand Threat Classification Series 19. Department of Conservation, Wellington, 23p.

Romano, T.A., Keogh, M.J., Kelly, C., Feng, P., Berk, L., Schlundt, C.E., Carder, D.A., Finneran, J.J., 2004. '*Anthropogenic Sound And Marine Mammal Health: Measures Of The Nervous And Immune Systems Before And After Intense Sound Exposure*'. Canadian Journal of Fisheries and Aquatic Sciences, 61, 1124-1134.

Rowantree, V.J., Valenzuela, L.O., Fraguas, P.F., Seger, J 2008, "*Foraging behaviour of southern right whales (Eubalaena australis) inferred from variation of carbon stable isotope ratios in their baleen*", Report to the International Whaling Commission, SC/60/BRG23.

Rowe, S., 2007. '*A Review Of Methodologies For Mitigating Incidental Catch Of Protected Marine Mammals*'. DOC Research and Development Series 283. Department of Conservation, Wellington.

Royal Society of Canada 2004. *"Report of the Expert Panel on Science Issues Related to Oil and Gas Activities, Offshore British Columbia*". An Expert Panel Report Prepared by the Royal Society of Canada at the request of Natural Resources Canada, Ottowa, ON.

Santulli, A., Modica, A., Messina, C., Ceffa, L., Curatolo, A., Rivas, G., Fabi, G., D'Amelio, V 1999. "*Biochemical responses of European sea bass (Dicentrarchus labrax L.) to the stress induced boy offshore experimental seismic prospecting*". Marine Pollution Bulletin, 38: 1105-1114.

Scofield, P., Stephenson, B 2013. *Birds of New Zealand: A photographic Guide*. Auckland University Press, Auckland, New Zealand.

Sekiguchi, K., Klages, N.T.W., Best, P.B., 1996. '*The Diet Of Strap-Toothed Whales (Mesoplodon Layardii)*'. Journal of Zoology (London) 239: 453-463.

Shirihai, H., Jarrett, B 2006, "*Whales, Dolphins and Other Marine Mammals of the World*", Princeton, Princeton University Press: 56-58.

Simmonds, M., Dolman, S., and Weilgart, L 2004. *Oceans of Noise 2004*. A Whale and Dolphin Conservation Science Report.

Širović, A., Hildebrand, J. A., Wiggins, S. M., McDonald, M. A., Moore, S. E., Thiele, D 2004, "*Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula*", Deep Sea Research Part II: Topical Studies in Oceanography, 51: 2327-2344.

Skalski, J., Pearson, W., Malme, C 1992. "*Effects of sounds from a geophyisical device on catch-per-unit-effort in a hook-and-line fishery for rockfish (Sebastes spp.)".* Canadian Journal of Fisheries and Aquatic Sciences, 49: 1357-1365.

Skilton, J, 2014, '*Statement of Evidence of Dr Jennifer Skilton for OMV New Zealand Ltd – Benthic Sediment'*, 17 September 2014, accessed from http://www.epa.govt.nz/EEZ/EEZ000007/EEZ000007_AppExWitness07_Skilton_Jennifer_BenthicSediment.pdf

Slooten, E., Dawson, S.M., Rayment, W.J., Childerhouse, S.J 2005, "*Distribution of Maui's dolphin, Cephalorhyncus hectori maui*", New Zealand Fisheries Assessment Report 2005/28. 21 p.

Slooten, E., Rayment, W., Dawson, S 2006. "*Offshore distribution of Hector's dolphins at Bank's Peninsula, New Zealand: Is the Banks Peninsula Marine Mammal Sanctuary large enough?*", New Zealand Journal of Marine and Freshwater Research 40: 333-343.

Slotte, A., Hansen, K., Dalen, J., Ona, E., 2004. '*Acoustic Mapping Of Pelagic Fish Distribution And Abundance In Relation To A Seismic Shooting Area Off The Norwegian West Coast'*. Fisheries Research 67(2): 143-150.

SLR, 2017. 'Benthic Ecological Survey for the Oi-1 & Oi-2 Exploration Wells – Post-Drill Assessment'. Report No: 740.10025.00100-R01, 75pp.

SLR, 2017a. 'Ecological Benthic Monitoring – Ruru-2 and Ruru-3 Exploration Wells, 2017 Post-drill Survey'. Report No: 740.10041.0022-R01, 82pp.

SLR, 2017b. 'Benthic Ecological Survey for the Maui Platform Alpha – Annual Production Monitoring, Report No: 740.10041.0020-R01, 86pp.

SLR, 2017c. 'Annual Production Monitoring – Benthic Ecological Survey Maari Field', Report No: 740.10013.00340-R01.

Smith, M. E 2004. "*Noise-induced stress response and hearing loss in goldfish (Carassius auratus*)". Journal of Experimental Biology, 207: 427-435.

Snelder, T., Leathwick, J., Image, K., Weatherhead, M., and Wild, M 2005. '*The New Zealand Marine Environmental Classification'.* NIWA Client Report: CHC2004-071. Prepared for Ministry for the Environment.

Solan, M., Hauton, C., Godbold, J.A., Wood, C.L., Leighton, T.G., White, P. 2016. Anthropogenic Sources Of Underwater Sound Can Modify How Seidment-Dwelling Invertebrates Mediate Ecosystem Properties. Scientific Reports, 6:20540, DOI: 10.1038/srep20540.

Southall, B., Bowles, A., Ellison, W., Finneran, J., Gentry, R., Greene, C., Kastak, D., Ketten, D., Miller, J., Nachtigall, P., Thomas, J., Tyack, P 2007. "*Aquatic Mammals. Marine mammal noise exposure criteria: Initial scientific recommendations"*. Aquatic Mammals, 33.

Stanton, B. R 1973. "*Hydrological investigations around northern New Zealand*". New Zealand Journal of Marine and Freshwater Research, 7: 85-110.

Steiner, S., Bisig, C., Petri-Fink, A., Rothen-Rutishauser, B., 2016. '*Diesel Exhaust: Current Knowledge of Adverse Effects and Underlying Cellular Mechanisms'*. Arch. Toxicol., 90: 1541 – 1553.

Stimpert, A.K., DeRuiter, S.L., Southall, B.L., Moretti, D.J., Falcone, E.A., Goldbogen, J.A., Friedlaender, A., Schorr, G.S., Calambokidis, J. 2014. '*Acoustic and foraging behaviour of a Baird's beaked whale, Berardius bairdii, exposed to simulated sonar'*. Scientific Reports 4: 7031. DOI: 10.1038/srep07031.

Stone, C., Tasker, M 2006. "*The effects of seismic airguns on cetaceans in UK waters*". Journal of cetacean research and management, 8: 255-263.

Streever, B., Raborn, S., Kim, K., Hawkins, A., Popper, A., 2016. '*Changes In Fish Catch Rates In The Presence Of Air Gun Sounds In Prudhoe Bay, Alaska*'. Arctic 69(4): 346-358.

Sverdrup, A., Kjellsby, P.G., Kruger, P.G., Floys, R., Knudsen, F.R., Enger, P.S., Serck-Hanssen, G., Helle, K.B. 1994, '*Effects of Experimental Seismic Shock on Vasoactivity of Arteries, Integrity of the Vascular Endothelium and on Primary Stress Hormones of the Atlantic Salmon'*, Fish Biology, 45:973 – 995.

Tanui Waikato. 2013, '*Waikato-Tainui Environmental Plan'*, http://www.wrrt.co.nz/wp-content/uploads/EBook_FINAL_EP_Plan_sp.pdf

Taranaki Iwi Trust 2013. *Letter to Taranaki Regional Council: Proposed transfer of Sugar Loaf (Nga Motu) Islands Submission.*

Taranaki Regional Council, 2004. '*Inventory of Coastal Areas of Local or Regional Significance in the Taranaki Region'*. Prepared by Taranaki Regional Council, January 2004, pp. 168.

Taranaki Regional Council. 2016. '*Draft Coastal Plan for Taranaki'*. Prepared by Taranaki Regional Council. August 2016.

Taylor, G. A 2000, "*Action plan for seabird conservation in New Zealand. Part A, Threatened seabirds*", Dept. of Conservation, Biodiversity Recovery Unit, Wellington, N.Z.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008. 'Berardius arnuxii. The IUCN Red List of Threatened Species 2008: e.T2762A9478212'. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T2762A9478212.en. Downloaded on 19 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008a. '*Mesoplodon bowdoini. The IUCN Red List of Threatened Species 2008: e.T13242A3425144'.* http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13242A3425144.en. Downloaded on 20 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008c. '*Mesoplodon grayi. The IUCN Red List of Threatened Species 2008: e.T13247A3428839'*. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13247A3428839.en. Downloaded on 20 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008d. '*Mesoplodon layardii. The IUCN Red List of Threatened Species 2008: e.T13249A3429897*'. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13249A3429897.en. Downloaded on 20 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008e. '*Hyperoodon planifrons. The IUCN Red List of Threatened Species 2008: e.T10708A3208830'.* http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T10708A3208830.en. Downloaded on 20 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008f. '*Tasmacetus shepherdi. The IUCN Red List of Threatened Species 2008: e.T21500A9291409'.* http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T21500A9291409.en. Downloaded on 20 July 2017.

Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P., Pitman, R.L., 2008g. *'Ziphius cavirostris. The IUCN Red List of Threatened Species 2008: e.T23211A9429826'.* http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T23211A9429826.en. Downloaded on 20 July 2017.

Te Ara 2017. http://www.teara.govt.nz/en/sea-floor-geology/page-3

Te Ara, 2017. 'Recreational Sea Fishing'. https://teara.govt.nz/en/recreational-sea-fishing/page-1

Te Ara, 2017a. '*New Zealand Coastal Fish'*. https://teara.govt.nz/en/coastal-fish/page-1

Te Ara, 2017b. '*Eels'*. https://teara.govt.nz/en/eels

Te Ara, 2017c. 'Octopus in New Zealand'. https://teara.govt.nz/en/octopus-and-squid/page-4

Te Ara, 2017d. 'Squid in New Zealand'. https://teara.govt.nz/en/octopus-and-squid/page-5

Telfer, T., Sincock, J., Bryd, G., Reed, J 1987, "*Attraction of Hawaiian Seabirds to lights: Conservation efforts and effect of moon phase*", Wildlife Society Bulletin 15: 406-413.

Thomas, J., Kastelein, R., Supin, A. 1992. *Marine mammal sensory systems*. Plenum Press, New York.

Thompson, P., Brookes, K., Graham, I., Barton, T., Needham, K., Bradbury, G., Merchant, N 2013. "*Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises*". Proceedings of the Royal Society B: Biological Sciences, 280: 20132001.

Thompson, D., 2015. '*Seabirds of the South Taranaki Bight'*. Prepared for Trans-Tasman Resources Ltd, NIWA Client Report No: WLG2013-15, Updated November 2015, pp.9.

Thomsen, F., Franck, D., Ford, JKB 2001. '*Characteristics of whistles from the acoustic repertoire of resident killer whales (Orcinus orca) off Vancouver Island, British Columbia'*. Journal of the Acoustical Society of America 109 (3):1240 – 1246.

Todd, B 2014, "*Whales and Dolphins of Aotearoa New Zealand*", Te Papa Press, Wellington, New Zealand.

Tormosov, D. D., Mikhaliev, Y. A., Best, P. B., Zemsky, V. A., Sekiguchi, K., Brownell Jr., R. L 1998. "*Soviet catches of Southern Right Whales Eubalaena australis, 1951–1971. Biological data and conservation implications*", Biological Conservation 86: 185–197.

Torres , L 2012. "*Marine mammal distribution patterns off Taranaki, New Zealand, with reference to the OMV NZ Ltd petroleum extraction in the Matuku and Maari permit areas*", Report prepared by NIWA for OMV NZ Ltd. March 2012. Report number WLG2012-15.

Torres, L. 2013. '*Evidence for an unrecognised blue whale foraging ground in New Zealand*'. New Zealand Journal of Marine and Freshwater Research, 47: 235-248.

Torres, L., Klinck, H. 2016. '*Blue whale ecology in the South Taranaki Bight region of New Zealand: January-February 2016 Field Report'*. Oregon State University. March 2016.

Torres, L. G., P. C. Gill, B. Graham, D. Steel, R. M. Hamner, C. S. Baker, R. Constantine, P. Escobar-Flores, P. Sutton, S. Bury, N. Bott, and M. H. Pinkerton. 2015. "*Population, habitat and prey characteristics of blue whales foraging in the South Taranaki Bight, New Zealand*". SC/66a/SH6, International Whaling Commission.

Torres, L, Barlow, D., Hodge, K., Klinck, H., Steel, D., Baker, C.S., Chandler, T., Gill, P., Ogle, M., Lilley, C., Bury, S., Graham, B., Sutton, P., Burnett, J., Double, M., Olsen, P., Bott, N., Constantine, R., 2017. '*New Zealand blue whales: recent findings and research progress'*. Journal of Cetacean Research and Management, IWC, 2017.

Tracey D.M., Anderson O.F. & Naylor J.R. 2011, 'A Guide to Common Deepsea Invertebrates in New Zealand Waters. Third Edition', New Zealand Aquatic Environment and Biodiversity Report No. 86.

TRC 2009. *Taranaki Where We Stand – State of the Environment Report 2009*. Published by the Taranaki Regional Council. http://www.trc.govt.nz/assets/Publications/state-of-the-environment-monitoring/state-of-the-environment-report-200/full+report.pdf

TRC, 2010, '*Regional Policy Statement for Taranaki'*, Taranaki Regional Council, Stratford, 250p.

TRC 2015. *Taranaki Iwi Statutory Acknowledgements*. http://www.trc.govt.nz/appendix-iv/

TRC. 2016. 'Draft Coastal Plan for Taranaki'. Prepared by Taranaki Regional Council. August 2016.

Visser, I. N 2000, "*Orca (Orcinus orca) in New Zealand waters*", PhD Dissertation, University of Auckland, Auckland, New Zealand.

Visser, I.N 2007, "*Killer whales in New Zealand waters: status and distribution with comments on foraging*", Unpublished report (SC/59/SM19) to the Scientific Committee, International Whaling Commission.

Waitangi Tribunal. 1999. The Whanganui River Report. Wai 167. https://forms.justice.govt.nz/search/Documents/WT/wt_DOC_68450539/Whanganui%20River%20Report%201999.pdf

Wardle, C., Carter, T., Urquhart, G., Johnstone, A., Ziolkowski, A., Hampson, G., Mackie, D 2001. *"Effects of seismic air guns on marine fish*". Continental Shelf Research, 21: 1005-1027.

Webb, C., Kempf, N 1998, "*Impact of shallow-water seismic in sensitive areas*". Society of Petroleum Engineers Technical Paper. SPE 46722

Webster, T., Dawson, S., Rayment, W., Parks, S., Van Parijs, S. 2016. Quantitative analysis of the acoustic repertoire of southern right whales in New Zealand.J. Acoust. Soc. Am. 140(1): 322-333.

Weilgart, LS. 2007. A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology 20(2): 159 – 168.

Wetland Trust, 2017. 'Manawatu Estuary'. http://www.wetlandtrust.org.nz/Site/RAMSAR_CONVENTION/MANAWATU_ESTUARY.ashx

Whanganui, 2017. 'Port'. http://www.whanganui.govt.nz/our-district/about-district/port/Pages/default.asp

Whanganui, 2017a. 'Ferry Feasibility and Feedback Reports'. http://www.whanganui.govt.nz/our-district/major-projects/Port_Revitalisation/Ferryfeasibility/Pages/default.aspx

Wilewska-Bien, M., Granhag, L., Andersson, K., 2016. '*The Nutrient Load From Food Waste Generated Onboard Ships in the Baltic Sea'*. Marine Pollution Bulletin, 105: 359 – 366.

Wiseman, N., Parsons, S., Stockin, K.A., Baker, C.S 2011, "*Seasonal occurrence and distribution of Bryde's whales in the Hauraki Gulf, New Zealand*", Marine Mammal Science 27: E253 – E267.

Woodside 2007. '*Impacts of seismic airgun noise on fish behaviour: a coral reef case study'*.

Wursig, B., Lynn, S., Jefferson, T., Mullin, K., 1998. '*Behaviour Of Cetaceans In The Northern Gulf Of Mexico Relative To Survey Ships And Aircraft'*. Aquatic Mammals 24(1): 41-50.

Wursig, B., Duprey, N., Weir, J 2007, "*Dusky dolphins (Lagenorhynchus obscurus) in New Zealand waters: present knowledge and research goals*", DOC Research and Development Series 270. Department of Conservation, Wellington, New Zealand. 28 p.

Yin S. 1999. '*Movement patterns, behaviors, and whistling sounds of dolphin groups off Kaikoura, New Zealand [MS*]'. College Station: Texas A&M University.

Zaeschmar, J., Visser, I. N., Fertl, D., Dwyer, S., Meissner, A. M., Halliday, J., Berghan, J., Donnelly, D., Stockin, K. A 2013, "*Occurrence of false killer whales (Pseudorca crassidens) and their association with common bottlenose dolphins (Tursiops truncatus) off northeastern New Zealand*", Marine Mammal Science 30: 594 – 608.

APPENDIX A: Sound Transmission Loss Modelling Report

Todd Exploration Management Services Limited

18SBB3D Seismic Survey

Sound Transmission Loss Modelling

Report Number 740.10079.AU001

9 January 2018

Todd Exploration Management Services Limited

32-38 Molesworth Street

New Plymouth

4310 New Zealand

Version: v2.0

Todd Exploration Management Services Limited

18SBB3D Seismic Survey

Sound Transmission Loss Modelling

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Ground Floor, 503 Murray Street
Perth WA 6000 Australia

+61 8 9422 5900   +61 8 9422 5901
perth@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
740.10079.AU001	v2.0	9 January 2018	Binghui Li	Dan Govier	Dan Govier
740.10079.AU001	v1.0	5 January 2018	Binghui Li	Dan Govier	Dan Govier

Executive Summary

Todd Exploration Management Services Limited (TEMS) is proposing to acquire a short 5-day three dimensional (3D) marine seismic survey, namely, 18SBB3D Seismic Survey. SLR Consulting New Zealand Pty Ltd (SLR) has been engaged by TEMS to provide a Marine Mammal Impact Assessment (MMIA) and the requisite Sound Transmission Loss Modelling (STLM) services for the proposed seismic survey, to assist TEMS in achieving relevant regulatory approval to commence the seismic survey.

This report details the STLM study that has been carried out for the proposed survey, which includes the following three modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the array source, including its directivity characteristics;
- Short range modelling, i.e. prediction of the received sound exposure levels (SELs) over a range of 4 kilometres from the array source location, in order to assess whether the proposed survey complies with the regulatory mitigation zone SEL requirements, and
- Long range modelling, i.e. prediction of the received SELs over a range of 200 kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (i.e. South Taranaki Bight blue whale habitat; the West Coast North Island Marine Mammal Sanctuary and the Clifford and Cloudy Bay Marine Mammal Sanctuaries).

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

The acoustic source array configuration that will be used for the proposed survey is a Boltgun 5,085 cubic inch array. The array comprises 3 subarrays and each subarray has 8 active sources (two pairs of cluster acoustic sources and four single acoustic sources in each subarray). The array has an average towing depth of 7.5 m and an operating pressure of 2,000 pounds per square inch (PSI). The array source modelling illustrates strong array directivity which has significant angle and frequency dependence for the energy radiation from the array, as a result of interference between signals from different array elements, particularly the three sub-arrays.

The short range modelling prediction under the summer sound speed profile and the fine sand seabed sediment demonstrates that the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.5 km for the selected source location. However, at the selected source location, the maximum received SEL is above 171 dB re 1µPa^2·s at 1.0 km from the source.

The long range modelling shows that the received SELs at long range vary significantly at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations.

The maximum SELs received from the selected long-range modelling source location in the western direction at a distance of 200 km are predicted to be above 100 dB re 1µPa^2·s. The maximum SELs received along the South Taranaki Bight are predicted to be below 100 dB re 1µPa^2·s due to its shallow and up-slope bathymetric features. North of Farewell Spit, the maximum SELs are predicted to be 100 - 110 dB re 1µPa^2·s within the nearshore region (water depths 10 m - 50 m). Ambient ocean noise levels register about 100 dB re 1µPa^2·s so at these distances the source will have negligible effect on the marine environment.

Executive Summary

Due to the high attenuation along the shallow water sections along the propagation paths, the maximum SELs are predicted to be below 100 dB re 1µPa2·s at the West Coast North Island Marine Mammal Sanctuary in the north and the Clifford and the Cloudy Bay Marine Mammal Sanctuaries in the south.

Table of Contents

TABLES

Table of Contents

Table of Contents

1 INTRODUCTION

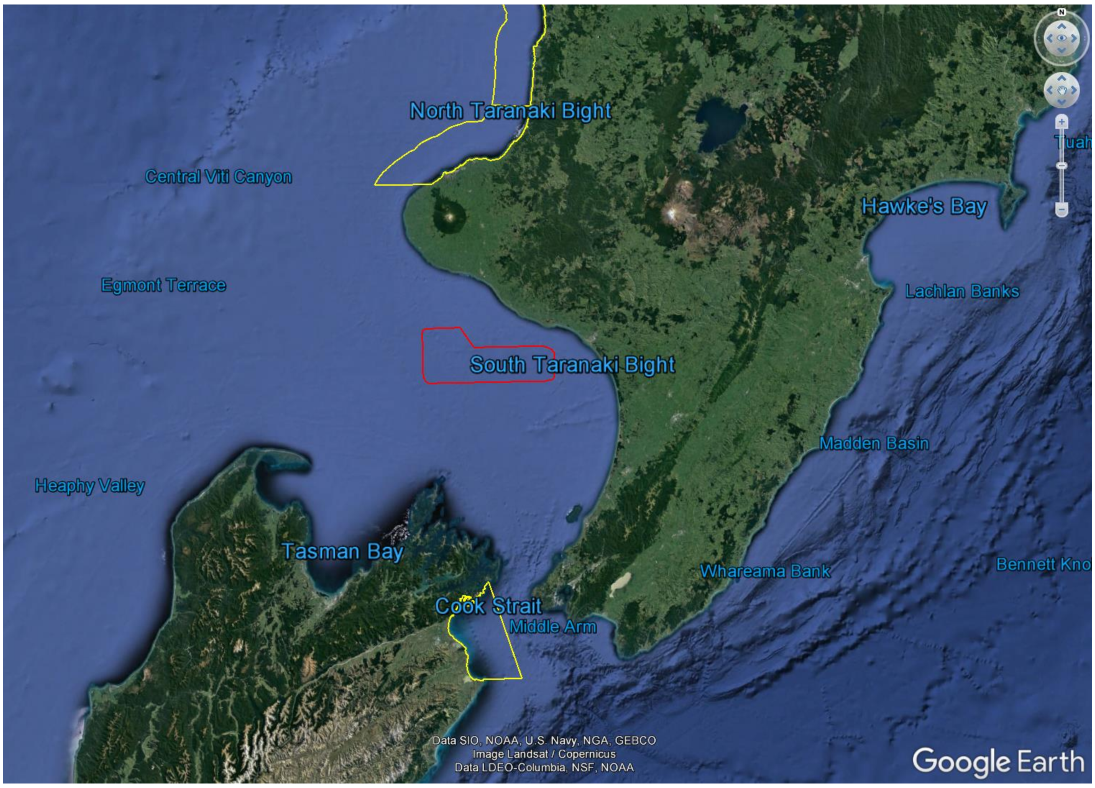
1.1 Project description

Todd Exploration Management Services Limited (TEMS) is proposing to acquire a short 5-day three dimensional (3D) marine seismic survey, i.e. 18SBB3D Seismic Survey. The survey area is located off South Taranaki in the South Taranaki Bight, with the survey Operational Area shown in **Figure 1**. TEMS is planning to undertake this survey in February 2018.

SLR Consulting NZ Ltd (SLR) has been engaged by TEMS to provide a Marine Mammal Impact Assessment (MMIA) and the requisite Sound Transmission Loss Modelling (STLM) services for the proposed seismic survey, to assist TEMS in achieving relevant regulatory approval to commence the seismic survey.

SLR has undertaken the STLM to verify mitigation zones and predict the received Sound Exposure Levels (SELs) that are produced from the survey. The modelling outputs have also been used to demonstrate whether the survey complies with the SEL statutory requirements in relation to the sound thresholds at the relevant mitigation zones within the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) (DOC, 2013).

Figure 1 Red polygon indicates the Operational Area of the proposed 3D seismic survey. Yellow polygons indicate the West Coast North Island Marine Mammal Sanctuary in the north, and the Clifford and the Cloudy Bay Marine Mammal Sanctuaries in the south.



1.2 Statutory requirements for sound transmission loss modelling (STLM)

In New Zealand, the Code was developed by the Department of Conservation (DOC) in consultation with a broad range of stakeholders in marine seismic survey operations. The Code came into effect on 29 November 2013.

The Code requires STLM to be undertaken to determine whether received SELs exceed 171 dB re 1µPa^2.s (behaviour criteria) at ranges of 1.0 km and 1.5 km from the source or 186 dB re 1µPa^2.s (injury criteria) at a range of 200 m from the source (DOC, 2013).

1.3 Structure of the report

This STLM study includes the following three modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the array source, including its directivity characteristics;
- Short range modelling, i.e. prediction of the received SELs within a 4 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 200 kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (i.e. South Taranaki Bight blue whale habitat, West Coast North Island Marine Mammal Sanctuary, and Clifford and Cloudy Bay Marine Mammal Sanctuary).

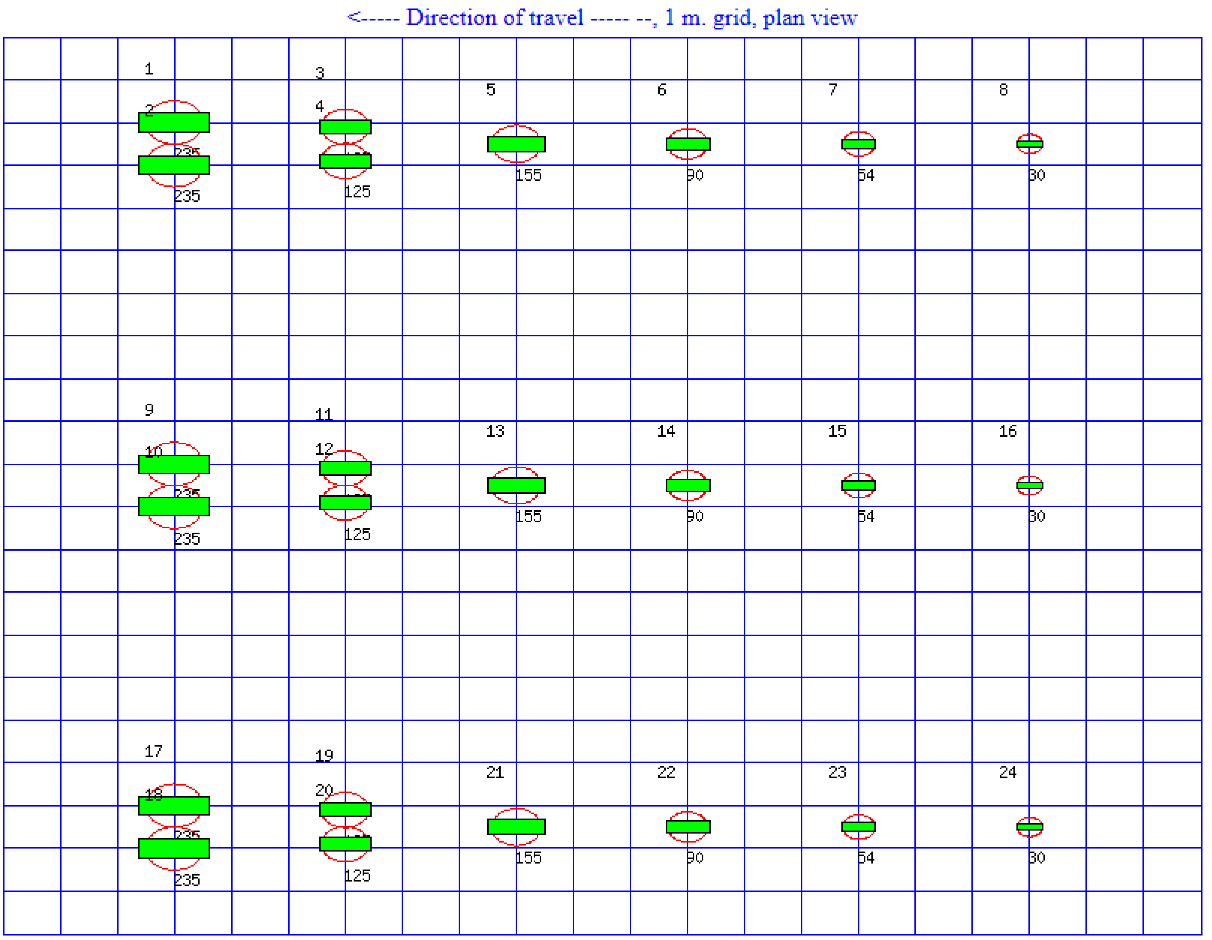
Section 2 of this report details the modelling methodology, procedure and results for the array source modelling. **Section 3** outlines the methodologies and procedures associated with the short and long range transmission loss modelling, with the major modelling results presented in **Section 4**.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

2 ACOUSTIC SOURCE ARRAY SOURCE MODELLING

2.1 Acoustic source array configuration

The acoustic source array that will be used for 18SBB3D Seismic Survey is a Boltgun 5,085 cubic inch array as shown in **Figure 2**. The array comprises three subarrays, and each subarray has eight acoustic source elements, arranged as either single acoustic sources or in clusters. For all 24 elements of the acoustic source array either 1500LL or 1900LLX acoustic sources have been selected. The array has an average towing depth of 7.5 m and an operating pressure of 2,000 pounds per square inch (PSI).

Figure 2 The configuration of the Boltgun 5,085 cubic inch array to be used in the 18SBB3D survey.



2.2 Modelling methodology

The required outputs of the acoustic source array source modelling for the subsequent sound modelling predictions include:

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

2.2.1 Notional signatures

The notional signatures are the pressure waveforms of each individual acoustic source, accounting for its interaction with other acoustic sources in the array, at a standard reference distance of 1 m.

Notional signatures are modelled using the Gundalf Designer software package (2015). The Gundalf acoustic source array source model is developed based on the fundamental physics of the oscillation and radiation of acoustic source bubbles as described by Ziolkowski (1970), taking into account non-linear pressure interactions between acoustic sources (Ziolkowski *et al*., 1982; Dragoset, 1984; Parkes *et al*., 1984; Vaages *et al*., 1984; Laws *et al*., 1988 & 1990).

The model solves a complex set of differential equations combining both heat transfer and dynamics, and has been calibrated against multiple measurements of both non-interacting acoustic sources and interacting cluster sources for all common acoustic source types at a wide range of deployment depths.

2.2.2 Far-field signatures

The notional signatures from all acoustic sources in the array are combined using appropriate phase delays in three dimensions to obtain the far-field source signature of the array in all directions from the source. This procedure to combine the notional signatures to generate the far-field source signature is summarised as follows:

- The distances from each individual acoustic source to nominal far-field receiving location are calculated. A 9 km receiver set is used for the current study;
- The time delays between the individual acoustic sources and the receiving locations are calculated from these distances with reference to the speed of sound in water;
- The signal at each receiver location from each individual acoustic source is calculated with the appropriate time delay. These received signals are summed to obtain the overall array far-field signature for the direction of interest; and
- The far-field signature also accounts for ocean surface reflection effects by inclusion of the “surface ghost”. An additional ghost source is added for each acoustic source element using a sea surface reflection coefficient of -1.

2.2.3 Beam patterns

The beam patterns of the acoustic source array are obtained as follows:

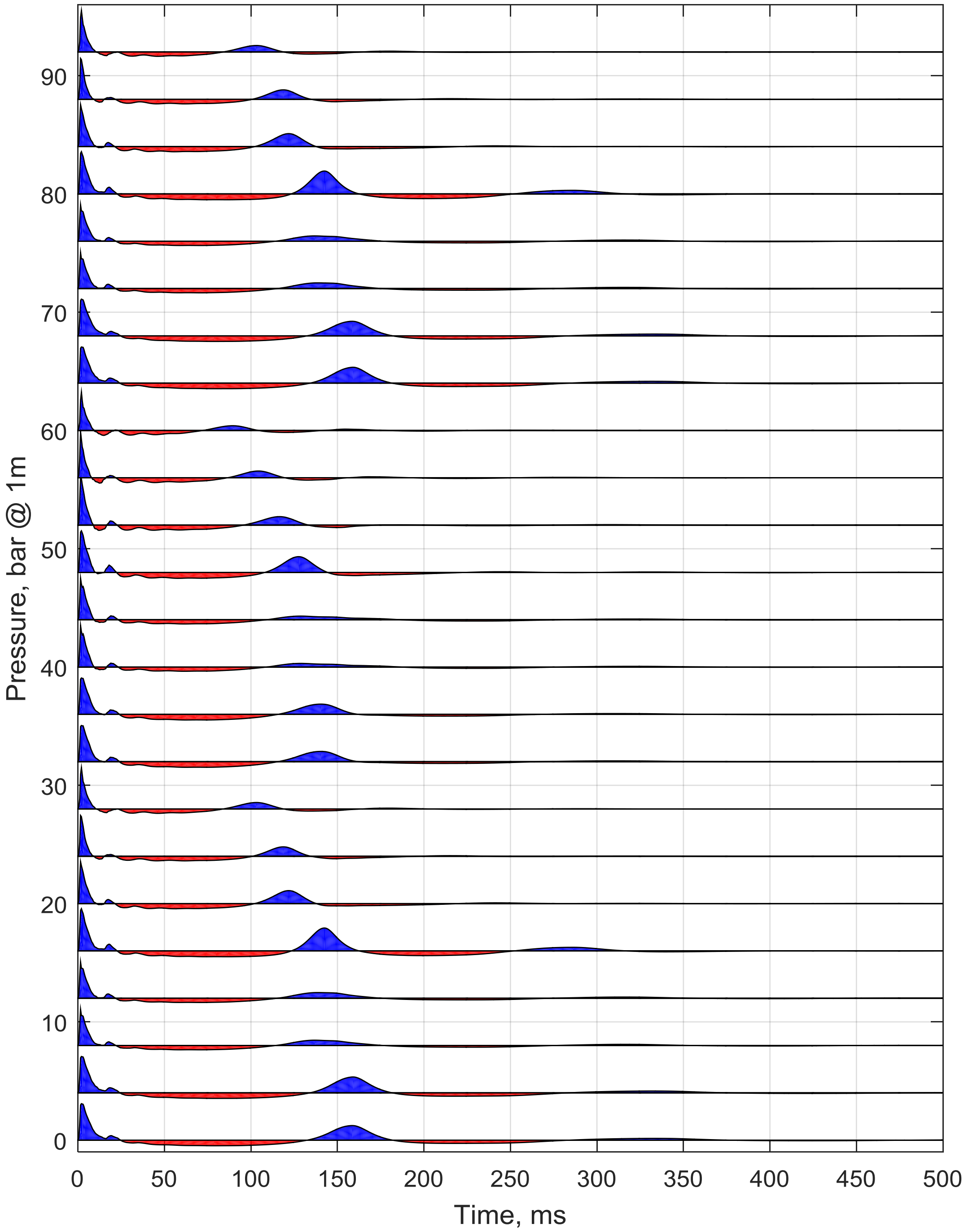
- The far-field signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The power spectral density (PSD) (dB re 1 µPa2s/Hz @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of all resulting signature waveforms are combined to form the frequency-dependent beam pattern for the array.

2.3 Modelling results

2.3.1 Notional signatures

Figure 3 shows the notional signatures for the 24 acoustic sources (eight acoustic sources per subarray) of the Boltgun 5,085 cubic inch array.

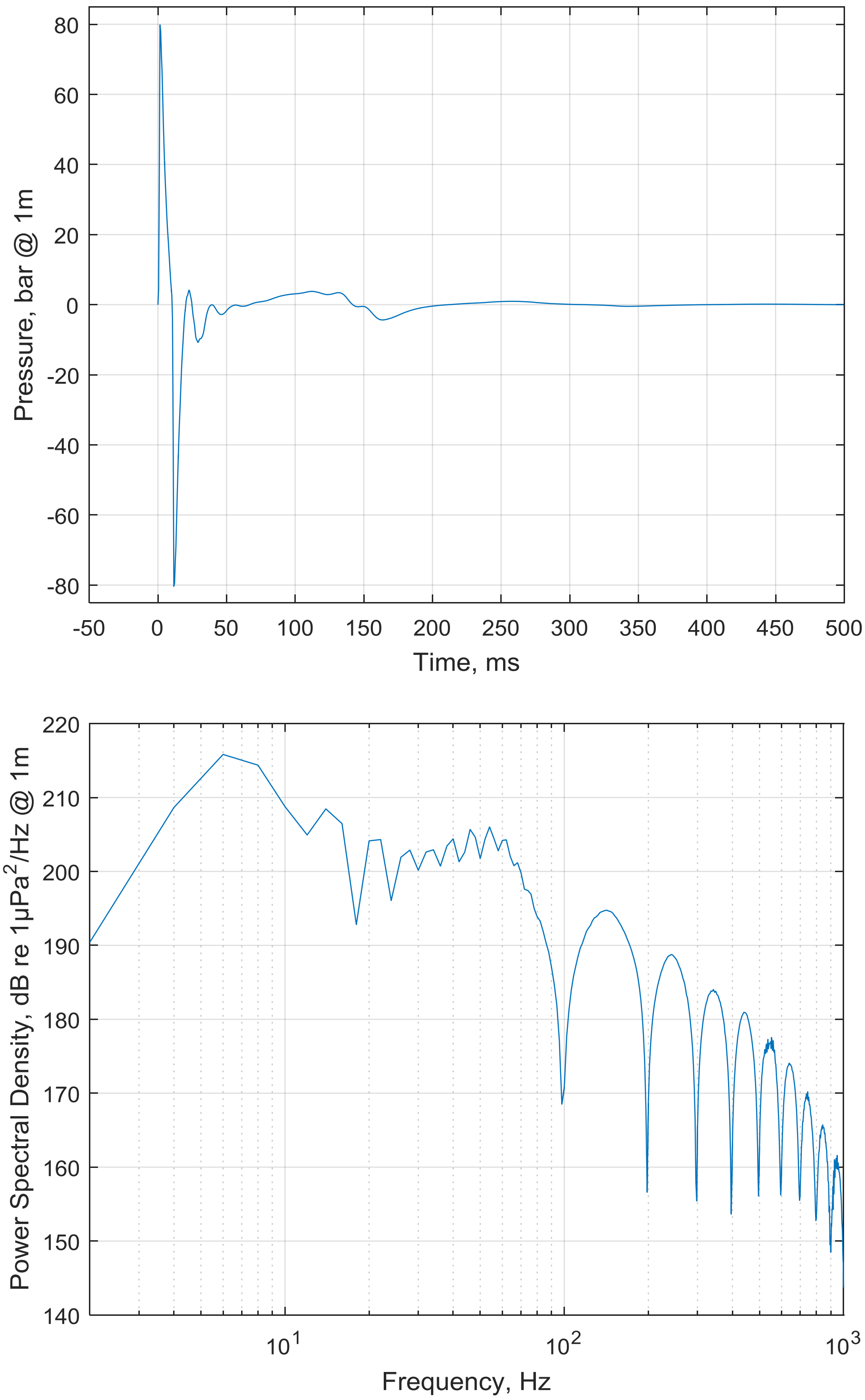
Figure 3 Notional source signatures for each individual acoustic source within the 24-acoustic source (3 sub-arrays) Boltgun 5,085 cubic inch array. Time series of positive pressure and negative pressure indicated by blue fill and red fill respectively. The scale is the same for the signatures from all acoustic sources.



2.3.2 Far-field signatures

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

Figure 4 The far-field signature in vertically downward direction (top) and its power spectral density (bottom) for the Boltgun 5,085 cubic inch array.



2.3.3 Beam patterns

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

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

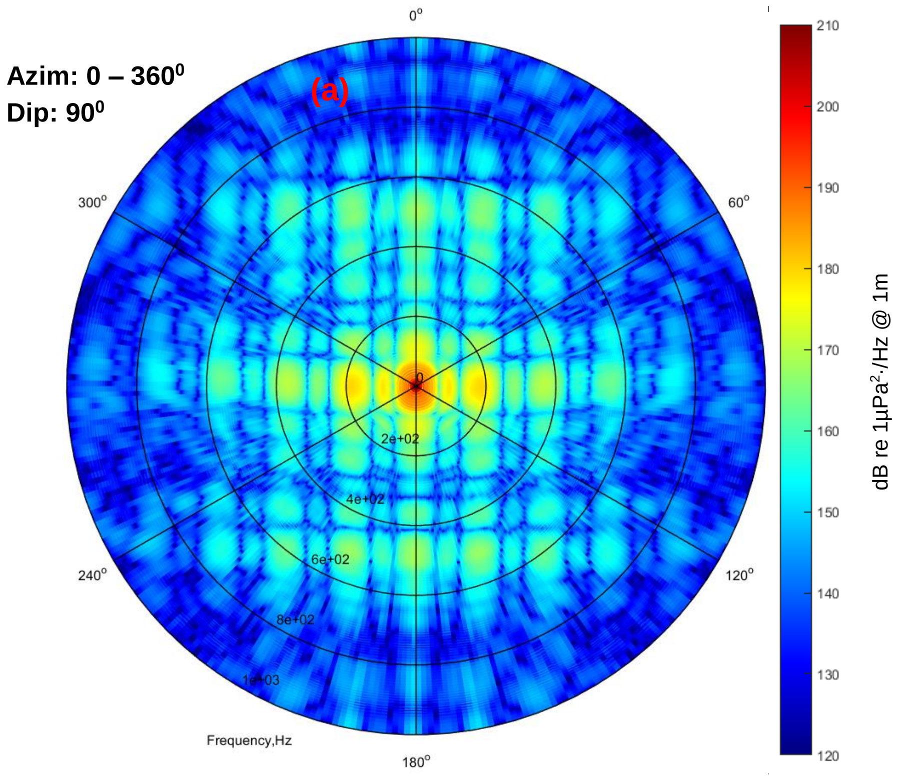
b. The vertical plane for the in-line direction (i.e. azimuthal angle of 0 degree) with dip angle of 0 degree corresponding to the vertically downward direction; and

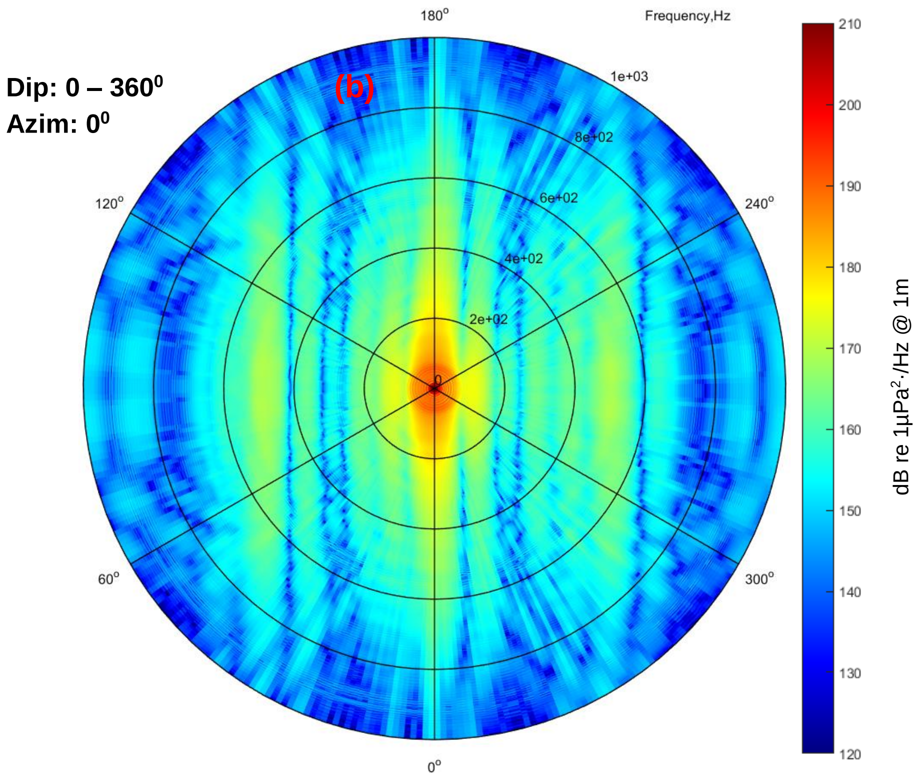
c. The vertical plane for the cross-line direction (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

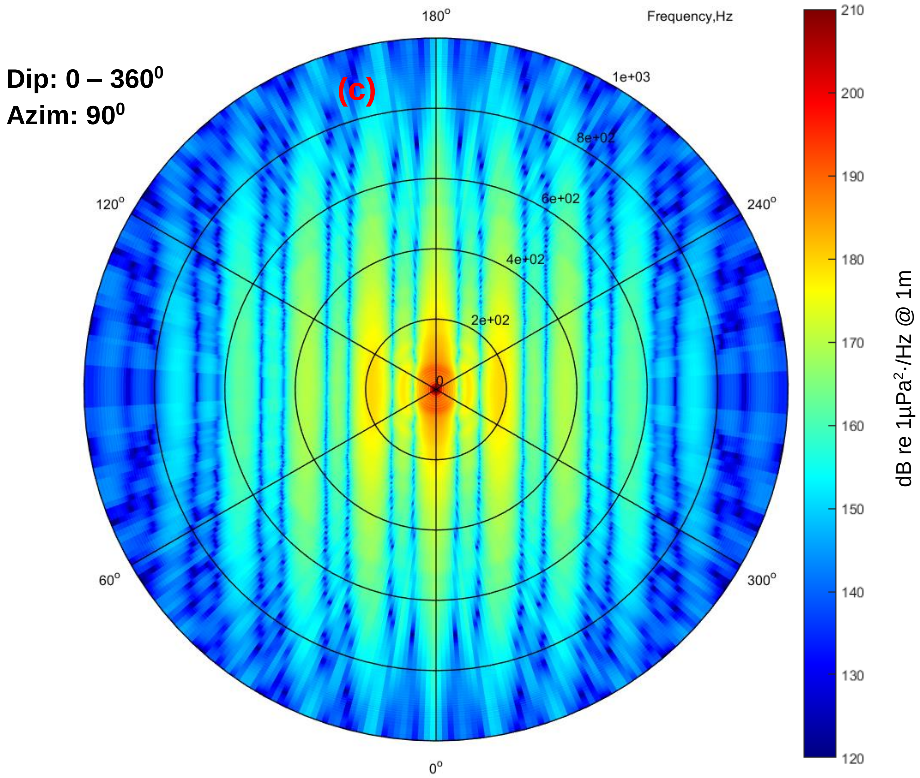
The beam patterns in **Figure 5** illustrate the strong angle and frequency dependence of the energy radiation from the array. The beam pattern of the horizontal plane shows relatively stronger energy radiation in the cross-line direction than in the in-line direction. The beam patterns of the in-line and cross-line vertical planes have the strongest radiation in the vertical direction.

The predominant frequency variation characteristics of these beam patterns are a result of interference between signals from different array elements, particularly from the three sub-array elements.

Figure 5 Array far-field beam patterns for the Boltgun 5,085 cubic inch array, as a function of orientation and frequency. (a) - The horizontal plane with 0 degree corresponding to the in-line direction; (b) – The vertical plane for the in-line direction; (c) – The vertical plane for the cross-line direction. 0 degree dip angle corresponds to vertically downward direction.




Dip: 0 – 360°
Azim: 0°
(b)
180°
Frequency,Hz
1e+03
8e+02
6e+02
4e+02
2e+02
0
120°
240°
60°
300°
0°
210
200
190
180
170
160
150
140
130
120
dB re 1µPa²·/Hz @ 1m


Dip: 0 – 360°
Azim: 90°
(c)
180°
Frequency,Hz
1e+03
8e+02
6e+02
4e+02
2e+02
0
120°
240°
60°
300°
0°
210
200
190
180
170
160
150
140
130
120
dB re 1µPa²·/Hz @ 1m

3 TRANSMISSION LOSS MODELLING

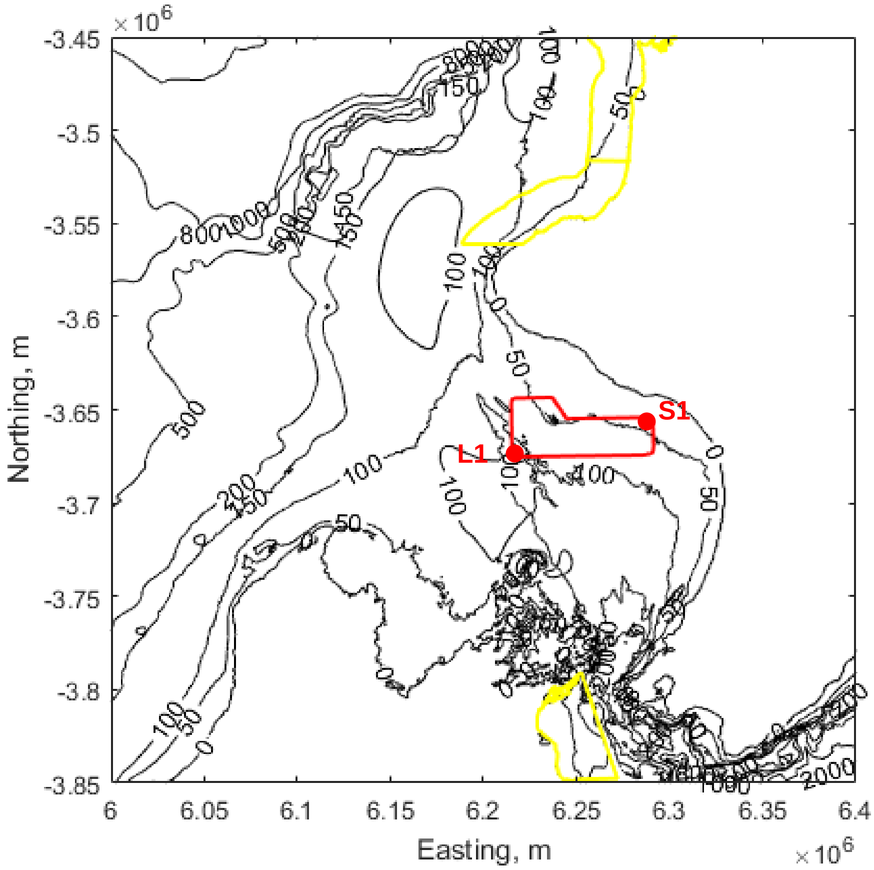
3.1 Modelling input parameters

3.1.1 Bathymetry

The bathymetry data used for the sound propagation modelling were obtained from the National Institute of Water and Atmospheric Research (NIWA) NZ Region 250 m gridded bathymetric dataset (CANZ, 2008). The corresponding project area bathymetric imagery with a resolution of 250 m is presented in **Figure 6**.

The short-range modelling location S1 was selected on the basis of its bathymetry being the shallowest water depths within the operational area (30 m). The long-range modelling location L1 was selected as it has the relatively deep water depth of around 100 m which favours the long range sound propagation, particularly towards the further offshore regions with deeper water depths.

Figure 6 The bathymetry contour overlaying the permit area. The coordinate system is based on Web Mercator Map Projection. Yellow polygons show the marine mammal sanctuary areas, red polygon is the proposed operational area. Red dots indicate the selected source locations for the short range (S1) and long range (L1) modelling case.



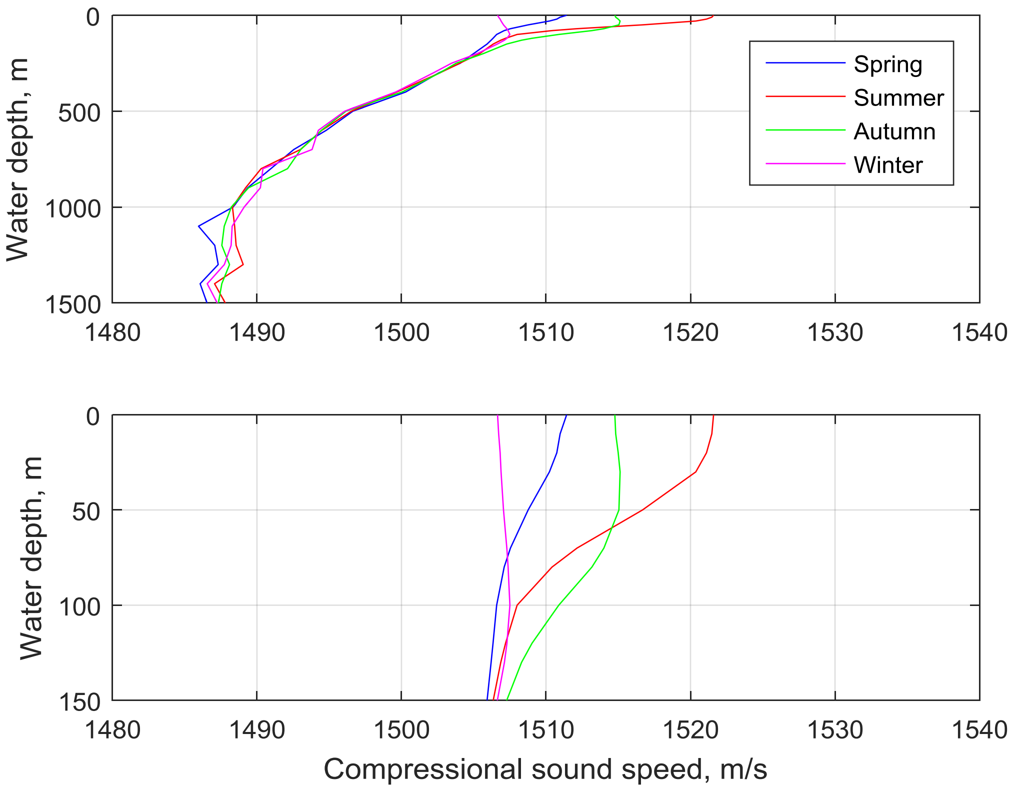
3.1.2 Sound speed profiles

Temperature and salinity data required to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (WOA09) (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure required to calculate the sound speed based on depth and latitude of each particular modelling location was obtained using Sanders and Fofonoff's formula (Sanders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

Figure 7 demonstrates the typical sound speed profiles in deep water region west of the North Island and in shallow water region close proximity to the survey area respectively for four southern hemisphere seasons. The most significant distinctions for the four profiles occur within the mixed layer near the surface. The spring and summer seasons have downwardly refracting near-surface profiles, with the summer profile having the stronger downwardly refracting feature. Both the autumn and winter seasons exhibit a surface duct, with the profile in the winter season having a stronger and deeper surface duct than that in the autumn season. Due to the stronger surface duct within the winter profile, it is expected that winter will favour the propagation of sound from a near surface acoustic source array. In descending order, the autumn, spring and summer seasons are expected to have relatively weaker sound propagation for a near-surface acoustic source array.

The proposed seismic survey is scheduled to occur in February 2018. Therefore, the sound speed profile of the summer season has been selected for all scenarios in this modelling study.

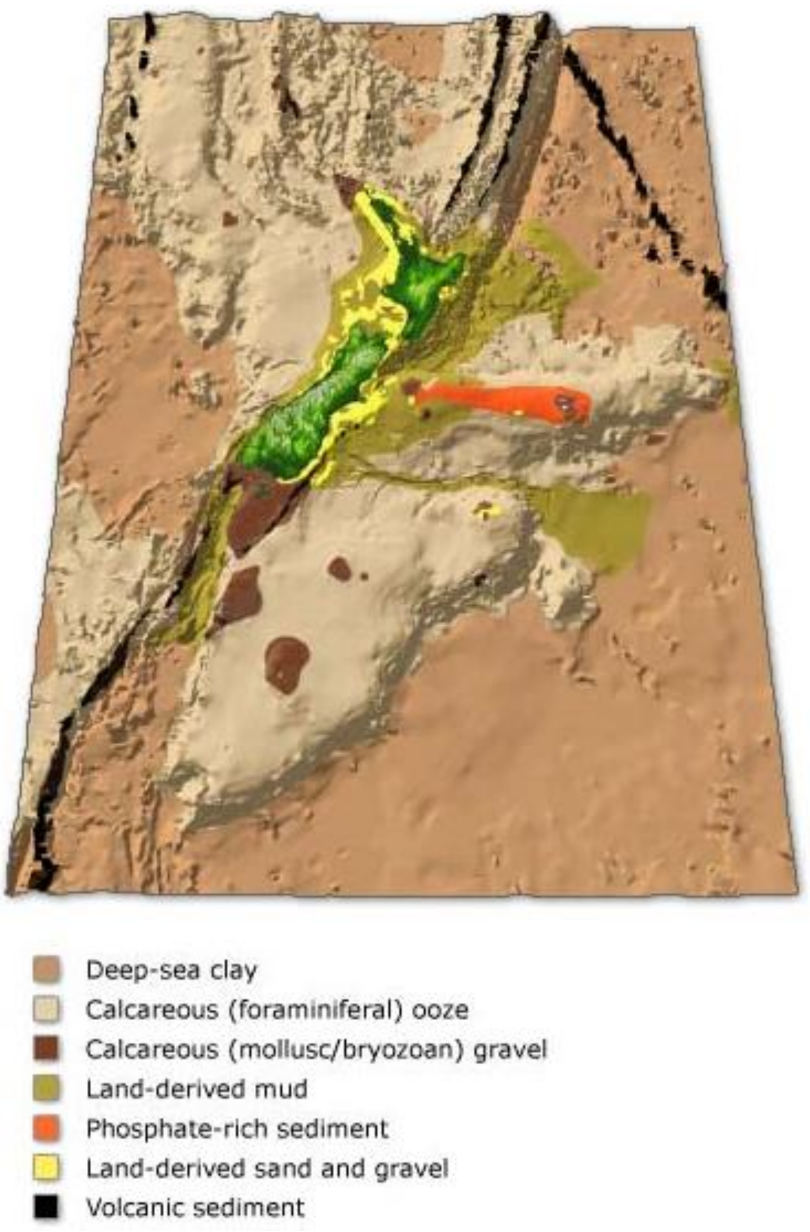
Figure 7 Typical sound speed profiles west and south of the North Island for different southern hemisphere seasons. Top panel shows profiles in deep water region, bottom panel shows profiles in the continental shelf near the Operational Area.



3.1.3 Seafloor geo-acoustic models

New Zealand has diverse seafloor sediments thanks to its variable and dynamic marine and terrestrial environments. NIWA has produced a variety of marine sediment charts illustrating the ocean bottom types around coastal New Zealand and some offshore areas. The map in **Figure 8** extracted from NIWA illustrates the distribution of the main types of marine sediments found on the ocean floor around New Zealand (Lewis *et al*., 2012 & 2013).

Figure 8 The distribution of the main types of marine sediment on the seafloor within coastal and offshore regions around New Zealand.



The continental shelf is covered mainly with land-derived sand, gravel and mud sediment, except at the northern and southern extremities where the shelly sediment from once-living sea creatures prevails due to the lack of major rivers. Within the Operational Area, off the western North Island, areas of black iron-rich sand have been formed by wave action on volcanic rock and via riverine input from Mount Taranaki.

The detailed sediment types for various relevant coastal and offshore regions are referred to in the New Zealand marine sediment charts and some technical reports (e.g. Matthew et al., (2014) and Galindo-Romero *et al*., (2014)). A summary of sediment types in and around the Taranaki Basin is provided in **Table 1.**

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

Region - West NZ	Sediment Type
Taranaki – Northland Continental Shelf	Dominant fine sand sediment with coarse sand sparsely scattered
Taranaki – Northland Continental Slope	Silt - clay
Southern New Caledonia Basin, Reinga Basin and Challenger Plateau	Pelagic sediments (mud – oozes, equivalent to silty clay)
Cook Strait	Fine sand

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 in Jensen *et al*. (2011). The elastic properties of sand, silt and clay are treated as negligible.

Table 2 Geoacoustic properties for various possible sediment types within the coastal and offshore regions 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 at the water/seabed interface for sediments of sand, silt and clay are presented in **Figure 9** and **Figure 10** respectively. As can be seen, the sandy seafloor sediments are more reflective than the silt and clay sediments, particularly at low grazing angles.

Figure 9 The reflection coefficients (magnitude - top panel and phase – bottom panel) for sand sediments (coarse sand, fine sand and very fine sand) at the seafloor.

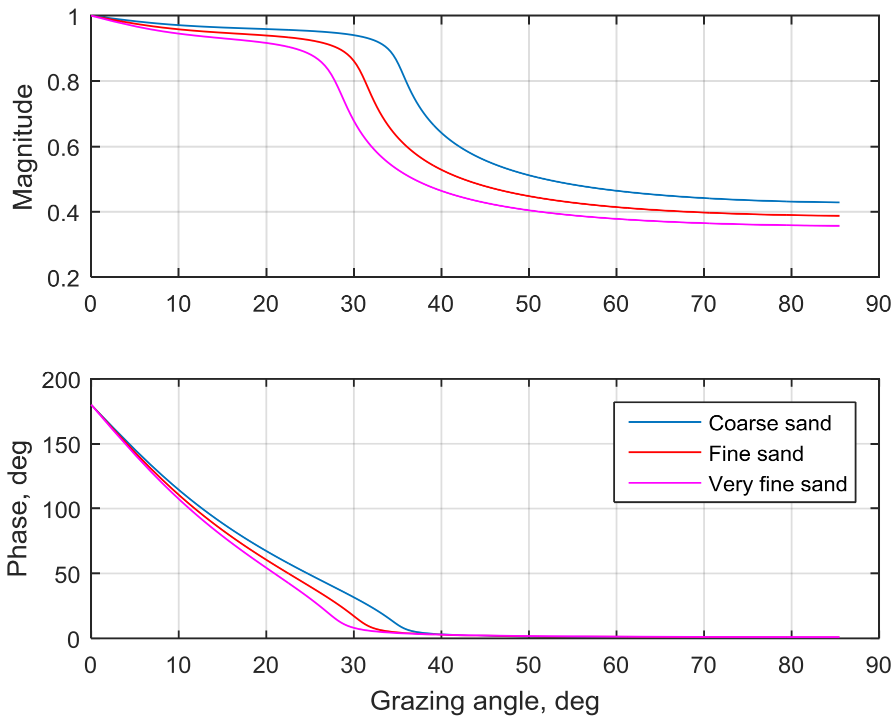
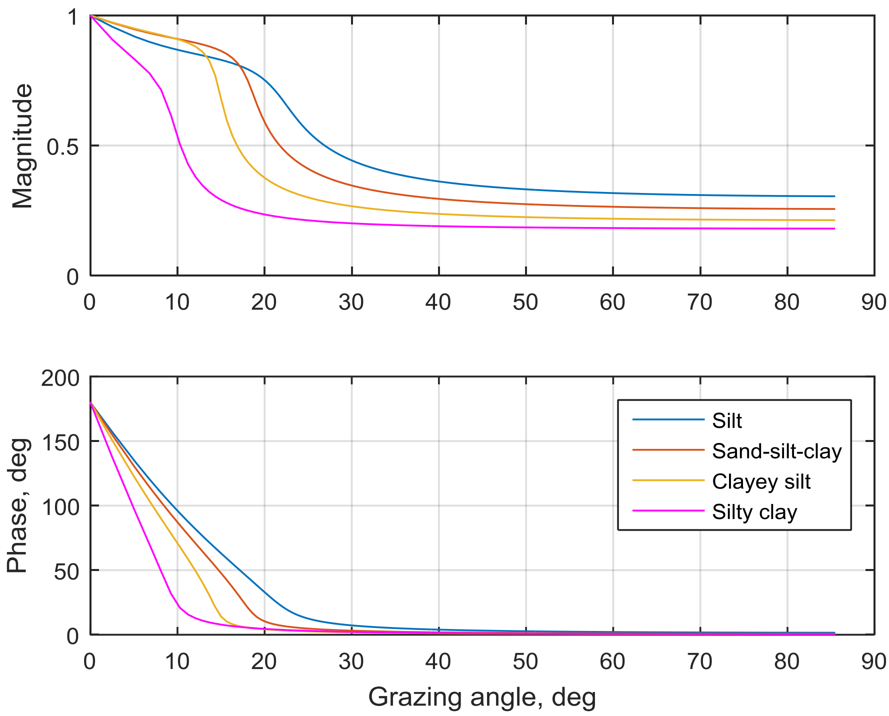


Figure 10 The reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay) at the seafloor.



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

The short range modelling is used to verify mitigation zones in relatively close proximity to the array source, and requires modelling predictions with high accuracy. In addition, interference between the signals arriving at any receiving location from different acoustic sources in the array is expected to be significant and complex for such a near-field scenario. To account for these considerations, the predictions for the short range case are modelled by adding or reconstructing the received signal waveforms from individual airgun source units within the array. The wavenumber integration modelling algorithm SCOOTER (Porter, 2010) is used to calculate the transfer functions (both amplitudes and phases) between sources and receivers. SCOOTER is a finite element code for computing acoustic fields in range-independent environments. The method is based on direct computation of the spectral integral, and is capable of dealing with an arbitrary layered seabed with both fluid and elastic characteristics.

The following procedure is followed to calculate received SELs:

7. The modelling algorithm SCOOTER is executed for frequencies from 1 Hz to 1 kHz, in a series of 1 Hz increments. The source depth of the Boltgun 5,085 cubic inch array is 7.5 m. A 1 m receiver grid in both range and depth with a maximum range up to 4 km is applied for the selected water depth. For each 1 m gridded receiver, the received SEL is calculated by following steps 2) – 5);
8. The range from each acoustic source in the array to each receiver is calculated, and the transfer function between each acoustic source and the receiver is obtained by interpolation of the results produced by modelling algorithm SCOOTER in Step 1). This interpolation involves both amplitude and phase of the transfer function;
9. The complex frequency domain signal of the notional signature waveform for each acoustic source is calculated via Fourier Transform, and multiplied by the corresponding transfer function from Step 2) to obtain the frequency domain representation of the received signal from that particular acoustic source;
10. The waveform of the received signal from each acoustic source is reconstructed via Inverse Fourier Transform. The received signal waveforms from all acoustic sources in the array are summed to obtain the overall received signal waveform; and
11. The overall signal waveform is squared and integrated to obtain the received SEL. Alternatively, the SEL value can also be calculated via integration of the energy power density over frequency in Step 3).

3.2.1.2 Modelling scenario

The source location as shown in **Figure 6** was selected for the short range modelling with their details provided in **Table 3**.

The modelling conditions for underwater noise propagation applicable to the proposed survey have been assumed for the short range modelling, i.e. the fine sand seabed sediment and summer season sound speed profiles.

Table 3 Details of the one selected source location for the short range modelling.

Source Location	Water Depth	Coordinates WGS84 [Easting, Northing]	Coordinates NZTM [x, y]	Locality
S1	30	[6,286,300, -3,654,600]	[1,746,583, 5,573,179]	Northeast corner of the Operational Area offshore South Taranaki Bight

3.2.2 Long range modelling

3.2.2.1 Modelling methodology and procedure

The long range modelling case requires reasonable accuracy of prediction as it generally involves complex and variable environmental factors such as sound speed profiles and bathymetric variations. Therefore, the modelling prediction for the long range case is carried out using the far-field source levels of octave frequency bands and their corresponding transmission loss calculations.

The fluid parabolic equation (PE) modelling algorithm RAMGeo (Collins, 1993) is used to calculate the transmission loss between the source and the receiver. RAMGeo is an efficient and reliable PE algorithm for solving range-dependent acoustic problems with fluid seabed geo-acoustic properties.

The received SEL's are calculated following the procedure outlined below:

12. One-third octave source levels for each azimuth to be considered are obtained by integrating the horizontal plane source spectrum over each frequency band, and these levels are then corrected to SEL levels;
13. Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 8 Hz to 1 kHz, with a maximum range of 200 km and at 5 degree azimuth increments. The bathymetry variation along each modelling track is obtained via interpolation from the CANZ (2008) dataset;
14. The one-third octave source SEL levels and transmission loss are combined to obtain the received SEL levels as a function of range, depth and frequency; and
15. The overall received SEL levels are calculated by summing all frequency band SEL levels.

3.2.2.2 Modelling scenarios

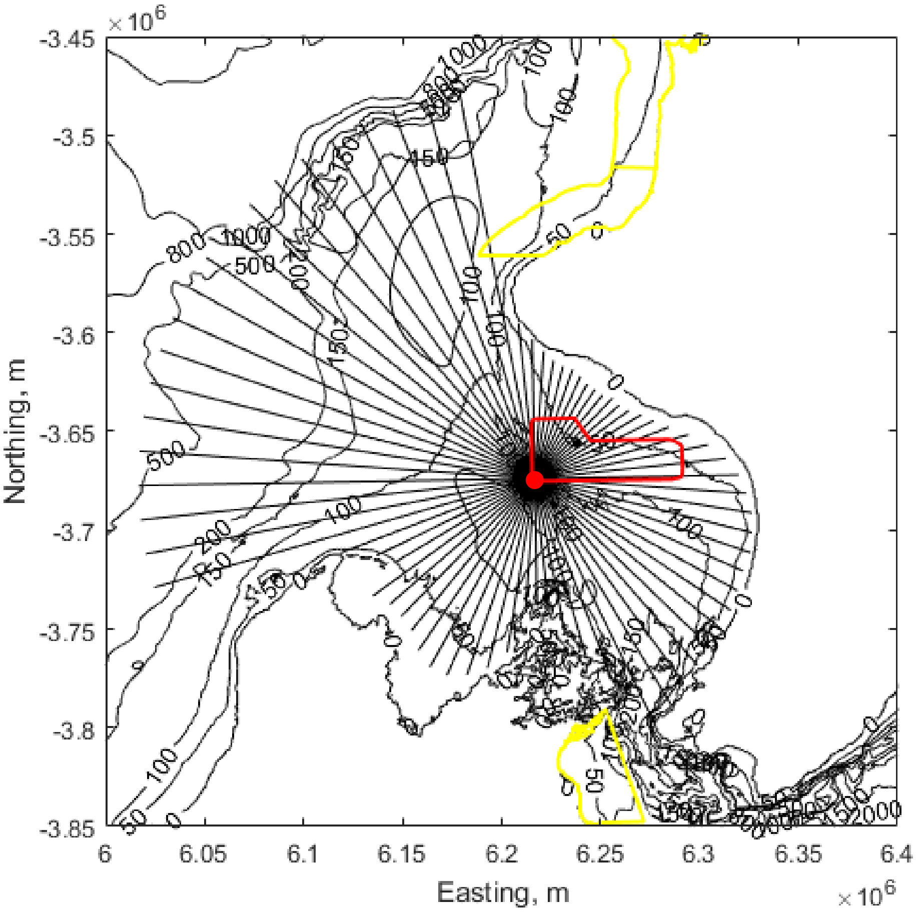
A single source location (L1 as shown in **Figure 11**) was selected for the long range modelling. Details of the selected source location are listed in **Table 4**. The summer season sound speed profile, along with the fine sand seafloor geoacoustic model (i.e. the predominant sediment type along the long range propagation path from the source location) has been used for the long range modelling as a worst case scenario.

The survey line orientation will be along the west to east direction.

Table 4 Details of the selected single source location for the long range modelling.

Source Location	Water Depth, m	Coordinates WGS84 [Easting, Northing]	Coordinates NZTM [x, y]	Locality
L1	101	[6,216,700, - 3,673,900]	[1,675,749, 5,554,649]	Southwest corner of the Operational Area offshore South Taranaki Bight

Figure 11 Long range modelling source location (red dot), with modelling sound propagation paths (black lines) overlaying local bathymetric contours. The coordinate system is based on WGS84 Web Mercator Map Projection.



4 RESULTS

4.1.1 Short range modelling

The received SEL levels from the Boltgun 5,085 cubic inch array for the selected source modelling location (S1) with the summer season sound speed profile and the fine sand seabed sediment have been calculated. 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 SELs in both the in-line and cross-line directions as a result of the directivity of the source array.

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 1µPa^2·s) and mitigation ranges (i.e. 200 m, 1.0 km and 1.5 km). The maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.5 km. However, the modelling results have shown that the SELs are above 171 dB re 1µPa^2·s at 1.0 km but meet the 171 db re 1µPa^2·s threshold at 1.2 km.

The predictions of the maximum SELs received at the three mitigation ranges are listed in **Table 5**. **Table 6** presents the ranges from the centre of the source array to where the predicted maximum SELs meet the threshold levels (186 dB and 171 dB re 1µPa^2·s).

Table 5 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the center of the Boltgun 5,085 cubic inch array for the source locations S1.

Source location	Water depth, m	Seafloor	SEL at different ranges, dB re 1µPa^2·s		
			200 m	1.0 km	1.5 km
S1	30	Fine sand	185.0	174.2	169.8

Table 6 Ranges from the center of the Boltgun 5,085 cubic inch source array where the predicted maximum SELs for all azimuths equal the SEL threshold levels for the source locations S1.

Source location	Water depth, m	Seafloor	Ranges complying with the following SEL thresholds, m	
			SEL < 186 dB re 1µPa^2·s	SEL < 171 dB re 1µPa^2·s
S1	30	Fine sand	170 m	1,350 m

Figure 12 The predicted maximum received SELs across the water column from the Boltgun 5,085 cubic inch array as a function of azimuth and range from the center of the array. 0 degree azimuth corresponds to the in-line direction. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

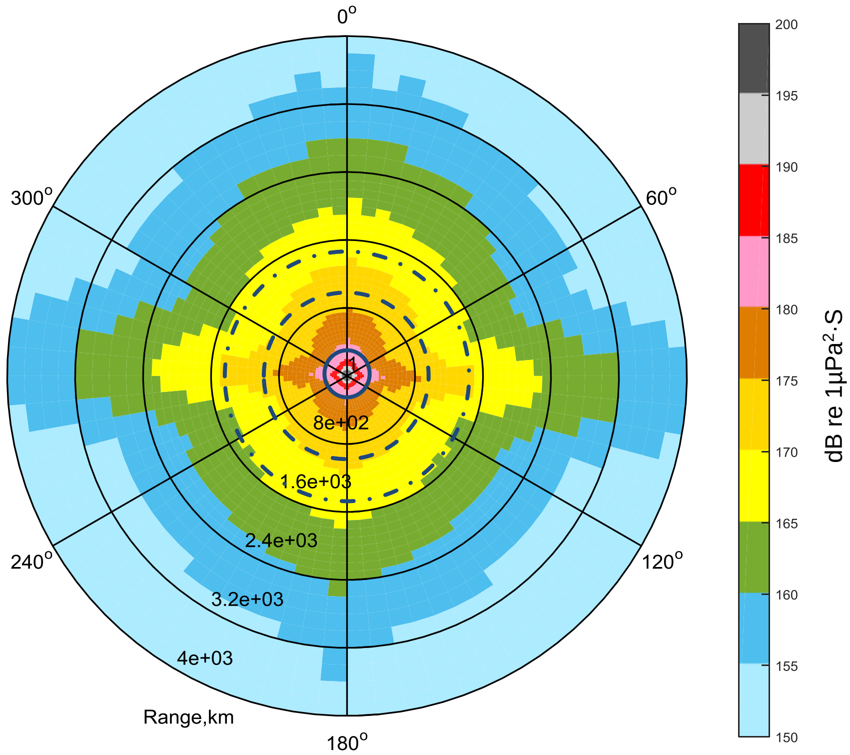
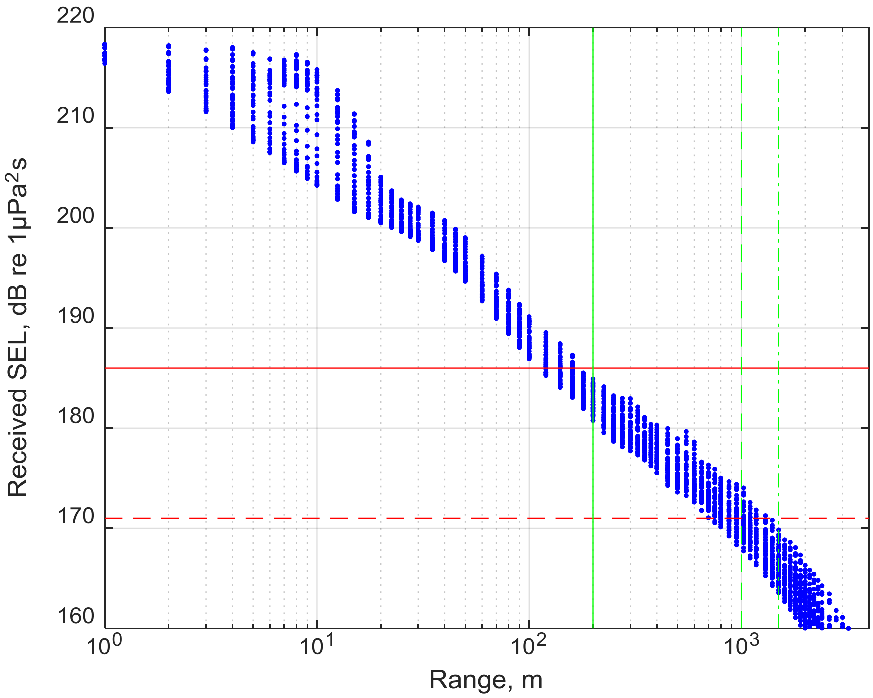


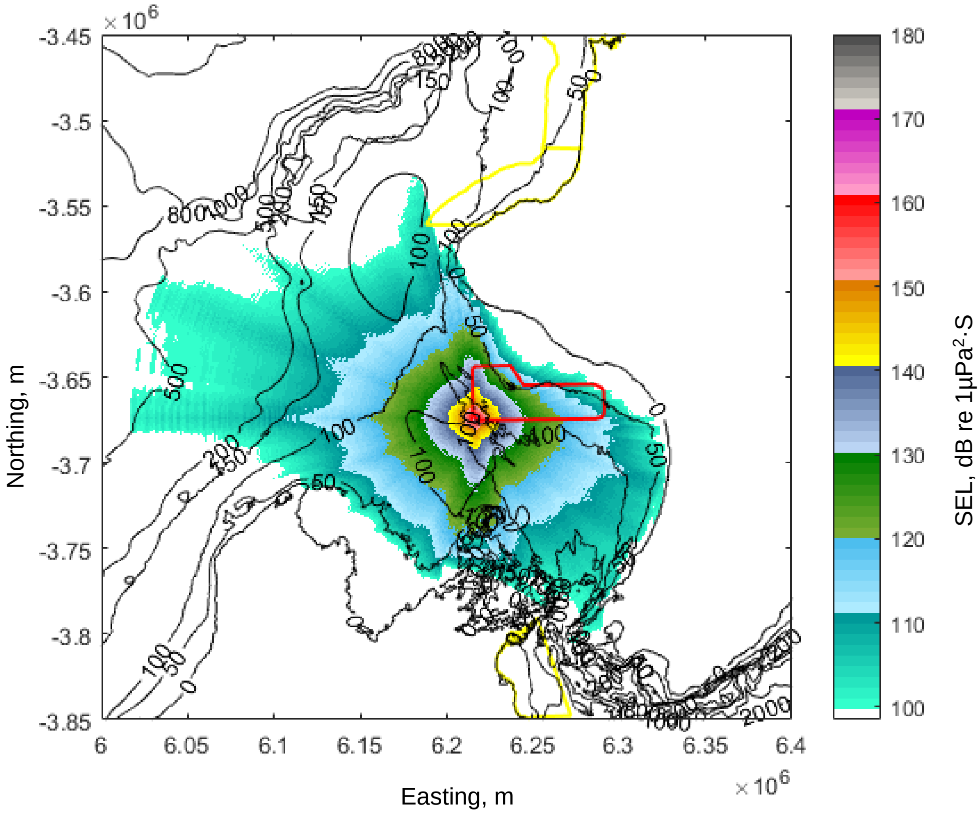
Figure 13 Scatter plots of predicted maximum SELs across the water column from the Boltgun 5,085 cubic inch array for all azimuths as a function of range from the center of the source array. Horizontal red lines show mitigation thresholds of 186 dB re 1µPa²·s (solid) and 171dB re 1µPa²·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).



4.1.2 Long range modelling

Figure 14 shows the contour image of the predicted maximum SELs received at locations up to 200 km from the long range source location (L1 in **Table 4**), overlaying the local bathymetry contours.

Figure 14 **Modelled maximum SEL (maximum level at any depth) contour (for source location to a maximum range of 200 km), overlaying with bathymetry contour lines.**



As can be seen from **Figure 14**, the received noise levels at far-field locations vary significantly at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations.

Figure 15 and **Figure 16** present the modelled SELs vs range and depth along the in-line west-east and east-west direction respectively. High noise attenuation is predicted for the propagation over the path sections with up-slope bathymetry profiles within the shallow water region in the eastern direction. The maximum SELs received in the western direction at a distance of 200 km are predicted to be around 100 dB re 1µPa^2·s.

Figure 17 and **Figure 18** present the modelled SELs vs range and depth along the cross-line north-south and south-north direction respectively. Relatively constant shallow water depths along the north-south direction favours the sound propagation due to the downward sound speed profiles and high reflections from the seabed at small grazing angles. Higher noise attenuations are predicted for the propagation path section along the shallower water area in the northern direction with up-slope bathymetry profiles.

The maximum SELs received along the southern reaches of the South Taranaki Bight are predicted to be below 100 dB re 1µPa^2·s due to its shallow and up-slope bathymetric features. North of Farewell Spit, the maximum SELs are predicted to be 100 - 110 dB re 1µPa^2·s within the nearshore region (water depths 10m - 50 m). These noise levels are barely above ambient noise levels in the ocean.

Due to the high attenuation along the shallow water sections along the propagation paths, the maximum SELs are predicted to be below 100 dB re 1µPa2·s at the West Coast North Island Marine Mammal Sanctuary in the north and the Clifford and the Cloudy Bay Marine Mammal Sanctuaries in the south.

Figure 15 Modelled SELs vs range and depth along the propagation path in west-east in-line direction from the source location. Black line shows the seabed depth variation.

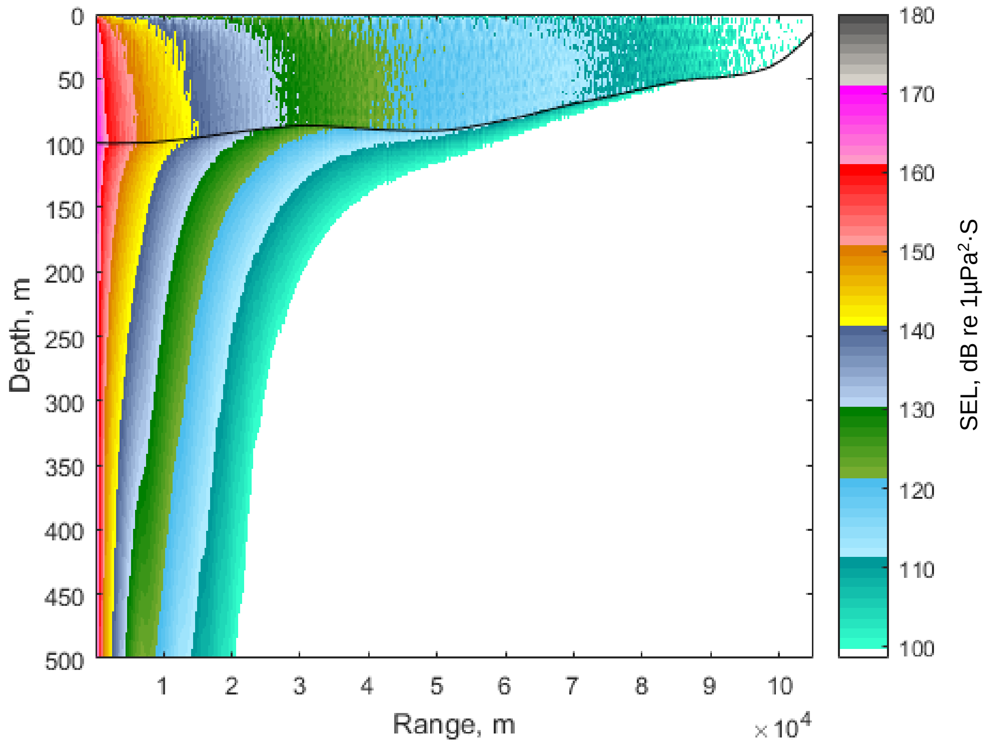


Figure 16 Modelled SELs vs range and depth along the propagation path in east-west in-line direction from the source location. Black line shows the seabed depth variation.

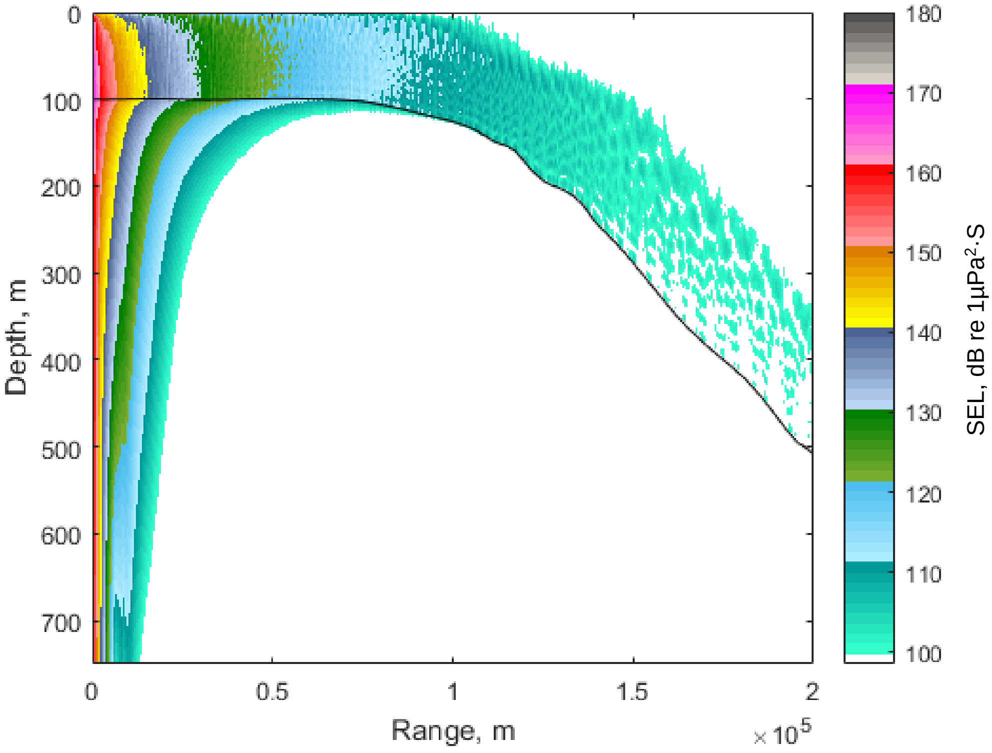


Figure 17 Modelled SELs vs range and depth along the propagation path in north-south cross-line direction from the source location. Black line shows the seabed depth variation.

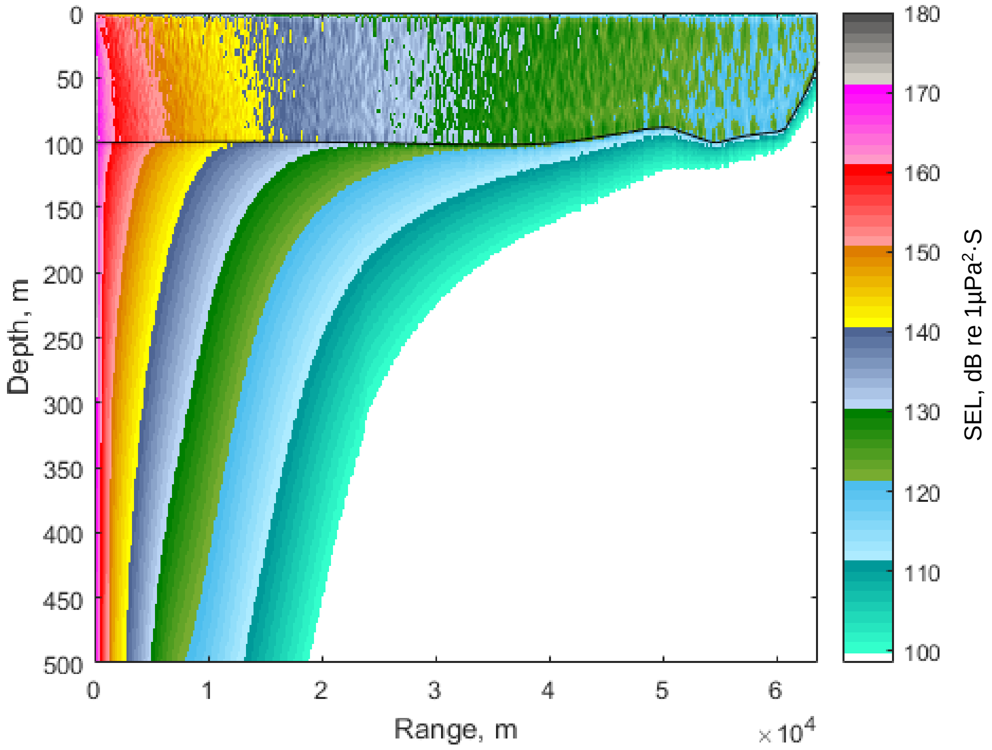
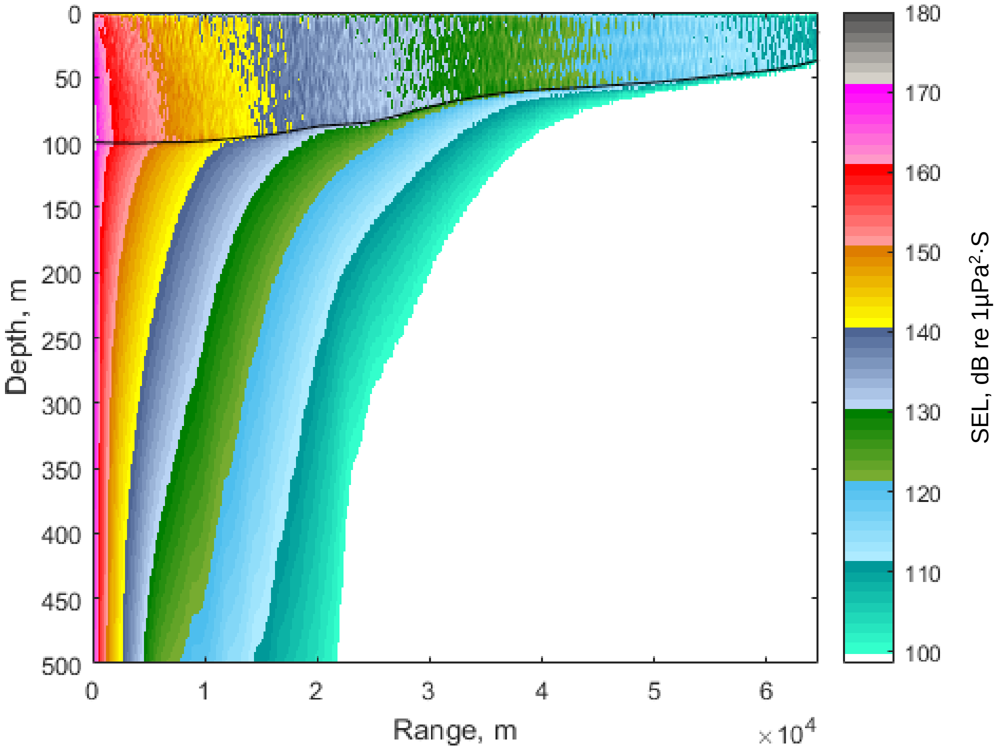


Figure 18 Modelled SELs vs range and depth along the propagation path in south-north cross-line direction from the source location. Black line shows the seabed depth variation.



5 CONCLUSIONS

TEMS is proposing to acquire a short 5-day 3D marine seismic survey, i.e. 18SBB3D Seismic Survey, in February 2018. This report details the STLM study that has been carried out for the proposed survey, which includes three modelling components - array source modelling, short range modelling and long range modelling. The detailed modelling methodologies and procedures for the three components are described in **Section 2** and **Section 3** of this report.

The acoustic source array configuration for the proposed survey is a Boltgun 5,085 cubic inch array. Source modelling of the array illustrates a strong array directivity which has significant angle and frequency dependence for the energy radiation from the array, as a result of interference between signals from different array elements, particularly the three sub-arrays.

The short range modelling 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 short range modelling prediction also demonstrates that under the summer sound speed profile and the fine sand seabed sediment the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.5 km for the selected source location. However, maximum received SELs are above 171 dB re 1µPa^2·s at 1.0 km from the source but meet this threshold at 1.2 km range.

The long range modelling shows that the received SELs at long range vary significantly at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations.

The maximum SELs received from the selected long-range modelling source location in the western direction at a distance of 200 km are predicted to be around 100 dB re 1µPa^2·s. The maximum SELs received along the southern reaches of the South Taranaki Bight are predicted to be below 100 dB re 1µPa^2·s due to its shallow and up-slope bathymetric features. North of Farewell Spit, the maximum SELs are predicted to be 100 - 110 dB re 1µPa^2·s within the nearshore region (water depths 10 m - 50 m). The maximum SELs are predicted to be below 100 dB re 1µPa2·s at the West Coast North Island Marine Mammal Sanctuary in the north and the Clifford and the Cloudy Bay Marine Mammal Sanctuaries in the south.

6 REFERENCES

Antonov, J. I., Seidov, D., Boyer, T. P., Locarnini, R. A., Mishonov, A. V., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, *World Ocean Atlas 2009, Volume 2: Salinity.* S. Levitus, Ed. NOAA Atlas NESDIS 69, U.S. Government Printing Office, Washington, D.C., 184 pp.

CANZ, 2008, New Zealand Region Bathymetry, 1:4 000 000, 2nd Edition, *NIWA Chart*, Miscellaneous Series No. 85.

Collins, M. D., 1993, A split-step Padé solution for the parabolic equation method, *J. Acoust. Soc. Am.*, 93: 1736-1742.

Del Grosso, V. A., 1974, New equation for the speed of sound in natural waters (with comparisons to other equations), *J. Acoust. Soc. Am*. 56: 1084-1091.

DOC, 2013. '*2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations*'. In Department of conservation (DOC) (Ed.) Wellington, New Zealand: Department of Conservation.

Dragoset, W. H., 1984, A comprehensive method for evaluating the design of airguns and airgun arrays, *16th Annual Proc. Offshore Tech. Conf*. 3: 75-84.

Galindo-Romero, M. and Duncan A., 2014, Received underwater sound level modelling for the Vulcan 3D seismic survey, *Project CMST 1323*, Centre for Marine Science and Technology, Curtin University.

Gundalf Designer, Revision AIR8.1f, 01 May 2015, Oakwood Computing Associates Limited. (https://www.gundalf.com/).

Hamilton, E. L., 1980, Geoacoustic modelling of the sea floor, *J. Acoust. Soc. Am*. 68: 1313:1340.

Jensen, F. B., Kuperman, W. A., Porter, M. B. and Schmidt, H., 2011, *Computational Ocean Acoustics*, Springer-Verlag New York.

Koessler, M. and Duncan, A., 2014, Received underwater sound level modelling for the Northwest Frontier seismic survey, New Zealand, *Project CMST 1329,* Centre for Marine Science and Technology, Curtin University.

Laws, R. M., Parkes, G. E., and Hatton, L., 1988, Energy-interaction: The long-range interaction of seismic sources, *Geophysical Prospecting*, 36: 333-348.

Laws, M., Hatton, L. and Haartsen, M., 1990, Computer Modelling of Clustered Airguns, *First Break*, 8(9): 331-338.

Lewis, K., Scott D. N., and Carter L., Sea floor geology - New Zealand sea-floor sediment, *Te Ara - the Encyclopedia of New Zealand*, updated 13 July 2012, URL: http://www.TeAra.govt.nz/en/sea-floor-geology/page-7.

Lewis, K., Scott D. N., and Carter L., Sea floor geology - How sediment forms, *Te Ara - the Encyclopedia of New Zealand*, updated 03 September, 2013, URL: http://www.TeAra.govt.nz/en/map/5615/new-zealands-marine-sediment.

Locarnini, R. A., Mishonov, A. V., Antonov, J. I., Boyer, T. P., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, *World Ocean Atlas 2009, Volume 1: Temperature.* S. Levitus, Ed. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 184 pp.

Parkes, G. E., Ziolkowski, A. M., Hatton L. and Haugland T., 1984, The signature of an airgun array: computation from near-field measurements – practical considerations, *Geophysics*, 49: 105-111.

Porter, M., 2010, Acoustics Toolbox in *Ocean Acoustics Library* (http://oalib.hlsresearch.com/).

Saunders, P. M. and Fofonoff, N. P., 1976, Conversion of pressure to depth in the ocean, *Deep-Sea Res*. 23: 109-111.

Vaage, S., Strandness, S. and Utheim, T., 1984, Signatures from single airguns, Geophysical Prospecting, 31: 87-97.

Ziolkowski, A. M., Parkes, G. E., Hatton, L. and Haugland, T., 1982, The signature of an airgun array: computation from near-field measurements including interactions, *Geophysics,* 47: 1413-1421.

Ziolkowski, A. M., 1970, A method for calculating the output pressure waveform from an airgun, *Geophys.J.R.Astr.Soc*., 21: 137-161.

APPENDIX A.1: ACOUSTIC TERMINOLOGY

Sound Pressure	A deviation from the ambient hydrostatic pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to reference pressure. The reference pressure underwater is P_{ref} = 1 μPa
Root-Mean-Square Sound Pressure Level (RMS SPL)	The mean-square sound pressure is the average of the squared pressure over some duration. The root-mean-square sound pressure level is the level of the root of the mean-square pressure against the reference pressure
Sound Exposure Level (SEL)	SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period
Power Spectral Density (PSD)	PSD describes how the power of a signal is distributed with frequency.
Source Level (SL)	The acoustic source level is the level referenced to a distance of 1m from a point source
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide.
Sound Speed Profile	A graph of the speed of sound in the water column as a function of depth

APPENDIX B: Engagement Register

February 2018 - Offshore Seismic Stakeholder Engagement

Company/Group Name	Title	First Name	Last Name	First Initial	Title/Position	Email	Address 1	Address 2	Address 3	City	Postcode		Information sheet sent	
Te Kotahitanga o Te Atiawa Trust		Wharehoka	Wano	W	Deputy Chair	whare@taranaki.iwi.nz	PO Box 1097	Taranaki Mail Centre		New Plymouth	4340		27/12/2018	
Te Korowai o Ngāruahine Trust		Louise	Tester	L	Kairangahau Matua (Social and Policy Initiatives Manager)	louise@ngaruahine.iwi.nz	50 High St	Hawera		Taranaki	4640	28/12 HM contacted Louise and advised DR would be in touch as a follow up. DR followed up on the 18/1 to arrange a meeting. LT advised that she would like to meet in the week commencing 29/1. A meeting has been arranged for the 29/2. Meeting held on the 29/1 as scheduled. Louise discussed that there will be a minor to moderate impact on certain resources assoicated with the cumulative impact of back to back seismic surveying over a number of months. There is a lack of research which has been done on fish stocks and other ecological base line data prior to the survey commencing so the impact on the ecosystem as a whole will be unkown. Louise is interested in establishing a type of working group or equivalent in advance of the next offshore seismic survey to attempt to assess the overall impact of the survey on the oceanic ecosystem. Louise is also concerned the activity is permitted and all that is required is the	27/12/2018	OUTSTANDING
Department of Conservation		Callum	Lilley	C		clilley@doc.govt.nz	PO Box 462			New Plymouth	4340		27/12/2018	
Department of	Dr.	David	Lundquist	D		dlundquist@doc.govt.nz	PO Box 10420			Wellington	6143	Out of office reply - 29 January	27/12/2018	
Department of		Kristopher	Ramm	K		kramm@doc.govt.nz	PO Box 10420			Wellington	6143	Out of Office reply - 5 January	27/12/2018	
Department of Conservation Head Office		Andrew	Baxter	A		abaxter@doc.govt.nz	PO Box 10420			Wellington	6143	09/01/2018 Andrew's letter was not attached however he was able to get one from David Lundquist. He wanted to get confirmation of timing for getting the MMIA through to DOC, and who this would be coming from. 10/11/2018, Andrew confirmed with SLR that they would be sending the MMIA through as he knew Helen McConnell and happened to be speaking with her, he also go confirmation that it was near completion.	27/12/2018	
Taranaki Regional Council		Colin	Mclellan	C		Colin.McLellan@trc.govt.nz	Private Bag 713	Stratford		Taranaki	4352	Out of office reply - 8 January.	27/12/2018	
Environmental Protection Authority		Verity	Steptoe	V		verity.steptoe@epa.govt.nz	Private Bag 63002			Wellington	6140	4/01/2018 reply clarifying a typo in our letter, that stated the EPA not DOC were responsible for approving the survey's MMIA.	27/12/2018	
Environmental Protection Authority		Matthew	Dean	M		matthew.dean@epa.govt.nz	Private Bag 63002			Wellington	6140	Out of office reply - 3 January	27/12/2018	
Deepwater Group		Richard	Wells	R		richard@resourcewise.co.nz						08/01/2018 - Richard responded to the original notification email which contained a letter requesting contact be made via phone. David Riley contacted Richard who requested GPS co-ordinates for the survey polygon. These were supplied. Richard is an advocate of the O&G industry.		
Southern Inshore Fisheries		Carol	Scott	C		cscott@southerninshore.co.nz	PO Box 175			Nelson			27/12/2018	
Cape Egmont Boat Club		Vicki	Loveridge	L		vickiwarps@xtra.co.nz	332 Baily Road			Warea	4381		27/12/2018	
Ohawe Boating and Angling Club		Samuel	Radford	S	Secretary	radfordmichelle@hotmail.com	PO Box 272			Hawera	4620		27/12/2018	
Patea and Districts Boating Club		Harley	Ogle	H	Secretary	info@pateaboatingclub.co.nz	2/6 Turi Street	[P.O. Box 706]		Patea [Hawera]	4520 [4620]		27/12/2018	
Egmont Seafoods		Keith	Mawson	K		keith@egmontseafoods.co.nz	41 Centennial Dr			Moturoa	4310	08/01/2018 - reply stating he would circulate among local fisherman, and asked if we had notified Southern Inshore NZ and Deep Water Group, which we were able to confirm.	27/12/2018	
Taranaki Commercial Fishermen's Association		Ian	McDougall	I		compassrosefishing@xtra.co.nz							27/12/2018	
NZ Federation of Commercial Fishermen		Doug	Saunders-Loder	D		doug.loder@talleys.co.nz	PO Box 147			Motueka			27/12/2018	
Taranaki Recreational Fishing Council		Kevin	Moratti	K		krmoratti@xtra.co.nz	39 Ninia Road	Bell Block		New Plymouth			27/12/2018	
Port Taranaki		Guy	Roper	G	CEO	guyr@porttaranaki.co.nz	PO Box 348			New	4340	Out of office 15 January	28/12/2018	
New Plymouth Sport Fishing & Underwater Club		Rowan	Yandle	R		npsuc@xtra.co.nz	27 Ocean View Parade	Moturoa		New Plymouth	4310	05/01/2018 - response stating that the survey is of no concern to them, and that they will document the information at their next committee meeting.	28/12/2018	
Te Runanga o Ngati Ruanui Trust		Graham	Young	G		graham.young@ruanui.co.nz	74 Princes Street	Hawera		Taranaki	4610	DR called the office to contact Graham. Graham is away until the end of the month so I attempted to contact Maria Cashmore. She was away for the day so I forwarded her the consultation letter and asked her to come back to me 19.1.2018.	28/12/2018	
Ngati Rangi Trust						office@ngatirangi.com	1 Mountain Road	Ohakune Junction	PO Box 195	Ohakune	4660	Out of office - 9 January	28/12/2018	
Ngati Apa		Pahia	Turia	P		info@ngatiapa.iwi.nz	161 Bridge Street	PO Box 103		Bulls	4863		28/12/2018	
Manawhenua ki Mohua		Bev	Purdie	B		manawhenuakimohua@gmail.com							28/12/2018	
Whanganui Iwi Fisheries Forum													28/12/2018	
Te Kaahui o Rauru		Patrick	Nicola (or a lady called Mahalia)			admin@rauru.iwi.nz	14 Fookes Street			Waverley	4510	Called to follow up on the initial consultation letter. The receptionist advised that both Nicola and Mahalia are away today. She asked me to call back on Tuesday the 22/1/ to discuss. I called and spoke to Mahalia and she advised that Nicola is the key contact regarding this matter. Nicola won't be at work until the 24/25. Mahalia advised that if Nicola has any questions she will contact me (DR).	28/12/2018	
Department of Conservation - Takaka						takaka@doc.govt.nz	62 Commercial Street	[PO Box 166]		Takaka	7110 [7142]		28/12/2018	
Project Jonah						info@projectjonah.org.nz						Out of office - 4 January	28/12/2018	
Forest and Bird		Anton	van Helden	A	Marine Conservation Advocate	a.vanhelden@forestandbird.org.nz	PO Box 631			Wellington	6140	08/01/2018 - responded and accepted invitation to meet/discuss further. Asked to be supplied with the MMIA to ensure a 'meaningful discussion' and asked whether the array would be the same as that used by Schlumberger. 12/01/2018 communication sent that suggested we would not be able to send a copy of the MMIA until it was finalised. Anton replied asking if we would still give him sufficient time to comment prior to approval being provided by DoC. 17/01/2018 Hamish McHaffie replied notifiying of a miscommunication on our end and that we can share the MMIA in draft form and this was followed through. It was asked of Anton that any and all comments and questions be directed to Todd Energy only. Todd met with Anton van Helden on 31 January, a Marine Advocate at Forest & Bird, to discuss the MMIA for the 18SBB survey and the impacts of seismic on marine fauna in general. The discussion included disapproval of the 2013 Code and an open question as to why the revision of the Code has not been released. Key "takeaways" from the meeting were: - Anton voiced his appreciation to Todd for the opportunity to engage on our MMIA. Todd is the only company who has shared its MMIA with him before it goes to DoC for approval. He is somewhat cynical about the MMIA process as it stands, particularly with regard to engagement and he believes there should be more rigour introduced to the revised Code that was due for release last year. He further commented on the considerable work done on the review of the code and he hopes that agencies would look to adopt best practise and not just look to comply with an out of date code: o Seismic surveying to avoid calving periods at is the case as enforced by NOPSEMA in Australia o MMIAs need to become more streamlined – these documents are far too large for the general public to read or a plain language summary document should be included. o STLM could be more rigorous and include modelling up to the kHz range to account for beaked and toothed whales' calling and hearing, and it could also include metrics other than 1 second Sound Exposure Levels – he would like to see cumulative (24 hour) SELs included and that metrics used and discussed in MMIA are able to be readily compared to modelling models that are used. Todd indicated this could be reviewed for future surveys. He considers a 171 dB threshold in the 2013 Code, is not a level that has any biological relevance and at least the 160 dB threshold should be used as an interim measure for impulsive sounds (as per NOAA and NOPSEMA), Interim as behavioural disturbance is an area that is undergoing considerable debate. A very important deficiency of the 2013 code is that it does not account for behavioural disturbance in any meaningful way (e.g no consideration around masking). Anton believes that if avoidance due to elevated SELs causes species of concern to be displaced from a food source then that could constitute a "massive cost" to that species (e.g. for little blue penguins). There is also the real issue of animals not moving away because of dependence to an area and then being adversely exposed to higher noise levels.	28/12/2018	

Company/Group Name	First Initial	Title/Position	Email	Address 1	Address 2	Address 3	City	Postcode		Information sheet sent
University of Auckland	R	Marine Biologist(?)	r.constantine@auckland.ac.nz						Limited internet access to mid-January.	28/12/2018
Horizons Regional Council	?	?	help@horizons.govt.nz	Horizons Regional Council Office - Wanganui	181 Guyton Street		Wanganui		Out of office - 8 January	28/12/2018
Taranaki Regional	F		fred.mclay@trc.govt.nz							28/12/2018
Ngati Manuhiakai			ferinica.f@gmail.com	Horizons Regional Council Office - Wanganui					30/12/2017 Acknowledgment of email - "Thank you Brylee". 15.1.2018, DR emilaed Ferinica as a follow up to the initial consultation letter. Ferinica responded that they would like to hold a Hui on seismic testing. At this stage it is unclear whether the hui is related to onshore or off shore testing. I am awaiting a response. 31/1/2018 Ferinica confirmed the Hapu were interested in seismic survey's in general and would like an update. I responded and provided her with a copy of the draft MMIA.	28/12/2018
Whanganui River Maori Trust Board	B		berylmiller@xtra.co.nz							28/12/2018
Ngati Tu			george@manuirirangi.nz						Called Hori and left a message to call me back. I also sent and email - 19.1.2018. Hori emailed back on the 23.1.2018 and advised that he would like Todd to attend a Hapu Committee meeting and discuss the potential for effects of the survey operating on Kai Moana stocks. The meeting has been scheduled for Sunday the 3/2/2018. Hori emailed on the 29/1 and advised Todd had missed the Hui arranged partly to discuss the seismic survey. Todd extended an invitation to meet another time however due to Waitangi day, a	28/12/2018
Trans-Tasman	T	Executive	toka.walden@ttrl.co.nz						Out of office - 8 January	28/12/2018
NIWA	B	Chief Scientist - Coast and Oceans	Barb.Hayden@niwa.co.nz						Out of office - 9 January	28/12/2018
Port Taranaki (Acting CEO)	M		mwebb@porttaranaki.co.nz							28/12/2018
Otaraua Hapu	D		donna@otaraua.co.nz							29/12/2017
Ngati Rahiri Hapu	T	Chairperson	pam.ritai@xtra.co.nz						30/12/2017, response asking to notimate Zane Davey as a MMO on the ship. Hamish replied that he would try to action this and would come back to her with an answer.	29/12/2017
Oregon State University	L		Leigh.Torres@oregonstate.edu						16/01/2018 Leigh replied with the location of her hydrophone as we had asked if this could be shared for us to register it as a potential shipping hazard, she also requested a copy of our MMO report and sighting data from the survey. 18/01/2018 Brylee replied confirming that Todd would be happy to supply this report post survey, and asked if she could share when the hydrophone would be collected/removed for data harvesting. 18/01/2018 Leigh replied confirming the hydrophone will be in place for 2 years. On 2.02.2018 Dr Torres helpfully informed us the hydrophone was scheduled to be retreived from 3 Feb, however the hydrophone is 2-3 m from the seafloor in 70 m of water so will not conflict with the survey	11/01/2018
Te Whiringa Muka Trust	B		ben.potaka@wrmtb.co.nz						Initial letter was undelivered - sent for a second time 11/01/2017.	2/01/2018 & 11/01/2017
Fisheries Inshore New Zealand			info@inshore.co.nz							11/01/2018
WWF NZ	A		aleathers@wwf.org.nz						11/01/2018 Amanda reached out wanting some general answers around the MMIA process, we followed up with answers to these questions on 12/01/2018. No reply, from Amanda and again followed up on 17/01/2018 to no reply. MMIA was proactively shared with Amanda on 29/01/2018.	

APPENDIX C: Marine Mammal Mitigation Plan

global environmental solutions

18SBB3D Seismic Survey

Marine Mammal Mitigation Plan

Report Number 740.10079-R01

8 January 2018

Todd Exploration Management Services Limited

32-46 Molesworth Street

New Plymouth 4310

New Zealand

Version: v1.0

18SBB3D Seismic Survey

Marine Mammal Mitigation Plan

PREPARED BY:

SLR Consulting NZ Limited
Company Number 2443058
5 Duncan Street
Port Nelson 7010, Nelson New Zealand
(PO Box 5061, Port Nelson 7043 Nelson New Zealand)
+64 274 898 628
nelson@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10079-R01-v1.0	8 January 2018	Dan Govier	Helen McConnell	Dan Govier
740.10079-R01-v0.1	28 December 2018	Dan Govier	Helen McConnell	Dan Govier

Table of Contents

TABLES

FIGURES

1 INTRODUCTION

1.1 Purpose of the Marine Mammal Mitigation Plan

The purpose of this Marine Mammal Mitigation Plan (MMMP) is to outline the procedures to be implemented for the responsible operation of seismic activities around marine mammals during the '18SBB3D Seismic Survey'.

This MMMP will be used by observers and crew to guide operations in accordance with the Department of Conservation's (DOC) *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* ('Code of Conduct').

1.2 Survey Outline

Todd Exploration Management Services Limited (TEMS) is proposing to acquire a three dimensional (3D) marine seismic survey in the South Taranaki Basin. The Operational Area within which all seismic operations will be restricted is illustrated in **Figure 1**. While the actual area to be surveyed will be limited to about 320 km^2, the seismic operations (including line turns and other manoeuvring required by the seismic vessel) will occur within the approximate 1,856 km^2 Operational Area located between Hawera and Whanganui. This Operational Area encompasses a region known as the 'Patea Shoals'; and straddles both the Exclusive Economic Zone (EEZ) and the Coastal Marine Area (CMA). The coordinates of the Operational Area are provided in **Appendix 1.**

The Operational Area does not approach or enter any Marine Mammal Sanctuary. The closest marine mammal sanctuary is the West Coast North Island Marine Mammal Sanctuary which is located approximately 85 km to the north of the Operational Area. Water depths within the Operational Area range from 30 to 100 m.

The seismic survey is predicted to take about five days to complete, and is scheduled to commence in February 2018.

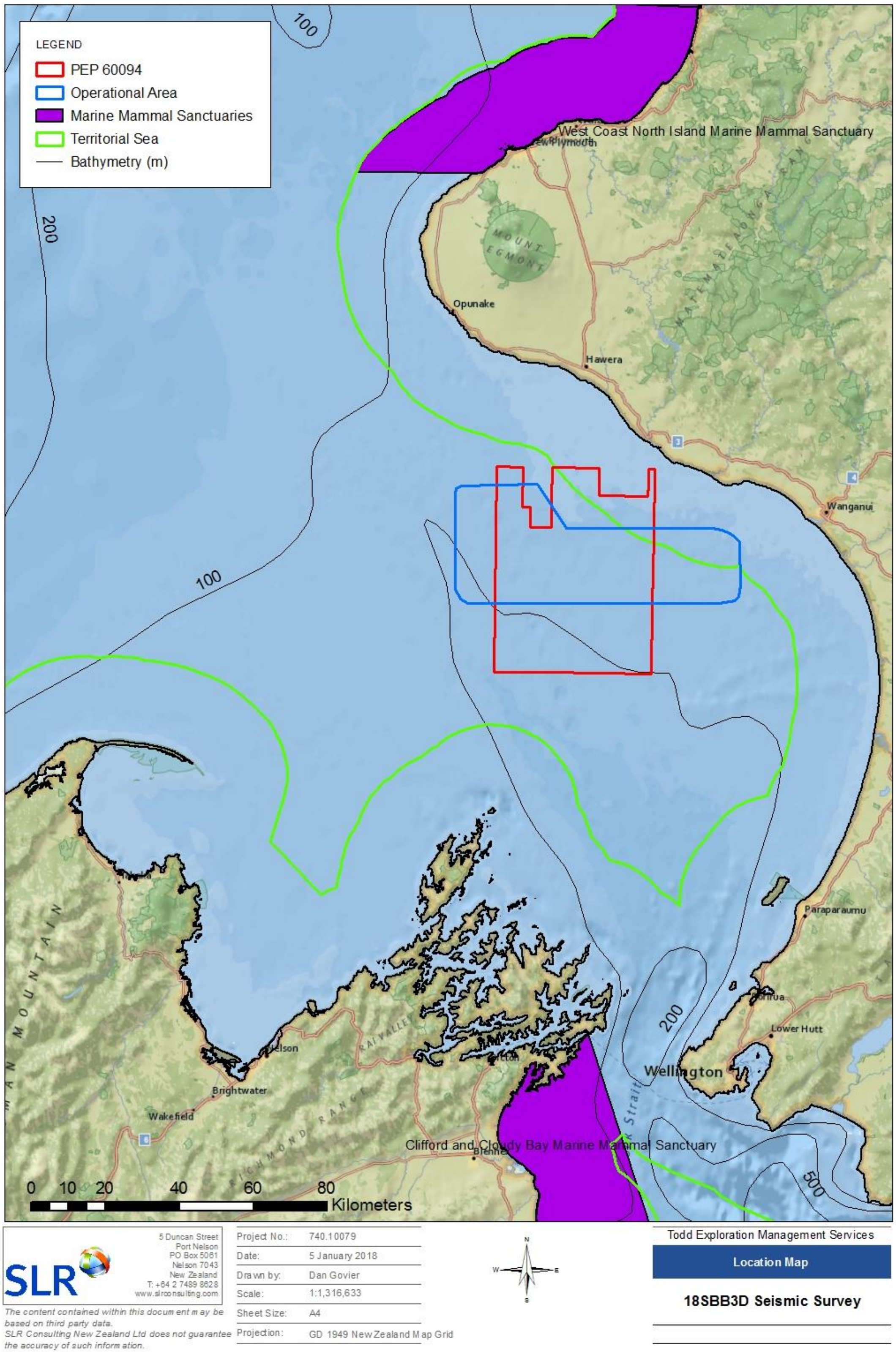
The *M/V Amazon Warrior* will undertake the surveys with an acoustic source volume of 5,085 in^3. The acoustic source will be activated at a source-point interval of 25 m. For a vessel speed of 4.5 knots, this equates to source activation every 10.8 seconds. In accordance with the Code of Conduct, the 18SBB3D Seismic Survey is classified as a Level 1 survey on account of the acoustic source being greater than 427 in^3.

The seismic vessel will tow 14 streamers that extend for approximately 8 km behind the vessel. Each streamer will be separated by 110 m; equating to an overall lateral span of up to 1,430 m. The streamers will remain deployed for the duration of the survey.

The seismic vessel will be accompanied by a support vessel which will serve to ensure a clear path for the seismic vessel, by alerting other marine users of the on-coming seismic vessel and its limited manoeuvrability. An additional chase vessel will also be present.

TEMS has been involved in seismic projects previously within the South Taranaki Basin in their exploration permit areas. Existing 2D seismic data within the proposed Operational Area is insufficient to provide an accurate subsurface image in this geologically complex area and Todd intends to ascertain whether the modern 3D technology available on the Amazon Warrior will adequately image the Taranaki Fault Zone. Hence the acquisition of modern broadband 3D seismic data, with high-resolution processing is required to assess the geological structure of the Taranaki Boundary Fault. If the 2018 3D seismic survey programme proves successful, TEMS may then propose further 3D seismic work to better understand the prospectively of the area in the future.

Figure 1 Operational Area for the 18SBB3D Seismic Survey



2 PROCEDURES FOR SEISMIC OPERATIONS

2.1 Standard Procedures

The procedures outlined below are stipulated by the Code of Conduct and represent the standard mitigations that operators implement for compliance with the Code of Conduct. **Section 2.2** describes the procedures that are over and above the standard mitigations and represent variations that are specific to the 18SBB3D Seismic Survey.

2.1.1 Notification

The notification requirements of the Code of Conduct have been adhered to. Notification was received by the Director-General of the Department of Conservation on 4 December 2017 notifying DOC of TEMS's intentions to carry out a short seismic survey in the Taranaki Basin.

2.1.2 Marine Mammal Impact Assessment

Under normal circumstances, a Marine Mammal Impact Assessment (MMIA) must be submitted to the Director-General not less than one month prior to the start of a seismic survey. However, for the 18SBB3D 3D Seismic Survey there was some uncertainty around timing and vessel availability of when and if the survey could commence due to the approval process for the preceding seismic survey. Following a detailed explanation to DOC, approval was subsequently provided in accordance with paragraph 2, Clause 3.1 of the Code of Conduct regarding the exceptional and opportunistic nature of the survey for the notification and submission requirements of the MMIA. Subsequently, the MMIA for the 18SBB3D Seismic Survey was submitted to DOC early in January 2018.

This MMMP forms part of the MMIA. Note that the term 'Species of Concern' is used both in the MMIA and the Code of Conduct, **Appendix 2** lists these species.

2.1.3 Observer Requirements

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

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

- There will be at least two qualified MMOs on-board at all times;
- There will be at least two qualified PAM operators on-board at all times;
- The roles of MMOs and PAM operators are strictly limited to the detection and collection of marine mammal sighting data, and the instruction of crew on the Code of Conduct and the crew's requirements when a marine mammal is detected within mitigation zones (including pre-start, soft start and operating at full acquisition capacity requirements). A summary of MMO and PAM operator duties are presented in **Table 1**;
- At all times when the acoustic source is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain 'watch' for marine mammals; and
- The maximum on-duty shift for an MMO or PAM operator must not exceed 12 hours per day. This includes reporting and any other duties not required by the Code (i.e. safety reports, etc.), not just on-watch time.

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:

16. Crew member to promptly report sighting to MMO;
17. If marine mammal remains visible then the MMO is to identify marine mammal and distance from acoustic source; and;
18. If a 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 1 Operational duties of qualified observers

MMO duties	PAM operator duties
Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.	Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.
Continually scan the water surface in all directions around the acoustic source for presence of marine mammals, using a combination of naked eye and high-quality binoculars from optimum vantage points for unimpaired visual observations.	Deploy, retrieve, test and optimise PAM hydrophone arrays.
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards or other appropriate tools.	When on duty, concentrate on continually listening to received signals and/or monitor PAM display screens in order to detect vocalising cetaceans, except when required to attend to PAM equipment.
Record/report all marine mammal sightings, including species, group size, behaviour/activity, presence of calves, distance and direction of travel (if discernible).	Use appropriate sample analysis and filtering techniques.
Record sighting conditions (Beaufort sea state, swell height, visibility, fog/rain and glare) at the beginning and end of the observation period, and whenever there is a significant change in weather conditions.	Record and report all cetacean detections, including, if discernible, identification of species or cetacean group, position, distance and bearing from vessel and acoustic source. Record the type and nature of sound, time and duration over which it was heard.
Record acoustic source power output while in operation, and any mitigation measures taken.	Record general environmental conditions, acoustic source power output while in operation, and any mitigation measures taken.
Communicate with DOC (+64 27 201 3478 or email at kramm@doc.govt.nz) to clarify any uncertainty or ambiguity in application of the Code of Conduct.	Communicate with DOC (+64 27 201 3478 or email at kramm@doc.govt.nz) to clarify any uncertainty or ambiguity in application of the Code of Conduct.
Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct.	Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct.

2.1.4 PAM Operations

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

If the PAM system malfunctions[2] or becomes damaged, seismic operations may continue for 20 minutes without PAM while the PAM operator diagnoses the problem. If it is found that the PAM system needs to be repaired, seismic operations may continue for an additional two hours without PAM as long as the following conditions are met:

- It is during daylight hours and the sea state is less than or equal to Beaufort 4;
- No marine mammals were detected solely by PAM in the relevant mitigation zones in the previous two hours;
- Two MMOs maintain watch at all times during seismic operations when PAM is not operational. This means that operations cannot continue at night if the PAM system malfunctions;
- DOC is notified via email (kramm@doc.govt.nz) 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.

Note that TEMS will ensure that 100% redundancy in equipment must be maintained on-board at all times during the 18SBB3D Seismic Survey.

2.1.5 Reporting Requirements

Qualified observers 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 a mitigation zone). The following standardised excel datasheets must be used:

- 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 each deployment. A written final trip report must also be provided to DOC at the earliest opportunity, but no later than 60 days after the completion of the project.

If qualified observers 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 Department of Conservation. Adaptive management procedures will be agreed following a discussion between DOC and the Operator. The MMO/PAM team will then implement any required adaptive management actions.

Incidents of non-compliance with the Code of Conduct must be reported immediately to DOC (+64 27 201 3478 or email at kramm@doc.govt.nz) and the EPA (seismic.compliance@epa.govt.nz). Within 48 hours of the initial notification of non-compliance a short summary of the incident should be sent by email to DOC and the EPA to provide a written record that outlines the nature of the non-compliance, where it occurred, when it occurred, why it occurred, how it occurred and any steps that have been taken to prevent reoccurrence.

2.1.6 Pre-start Observations

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

- The acoustic source cannot be activated during daylight hours unless:

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

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

New Location:

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

- MMOs have undertaken observations within 20 nautical miles of the planned start up position for at least the last two hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than two hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if:
  - PAM monitoring has been conducted for two hours immediately preceding proposed operations;
  - 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 (1,500 m for Species of Concern with or without calves and 200 m for Other Marine Mammals) in the two hours immediately preceding proposed operations;
  - No fur seals have been sighted during visual monitoring in the relevant mitigation zone (200 m) 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 (200 m) in the 30 minutes immediately preceding proposed operations.

For the 18SBB3D Seismic Survey, the proposed plan is for the Schlumberger Western Platform survey to finish with the well tie line into the Kupe Field. This well tie swath will enter into the TEMS Operational Area, with the intention to start acquiring the TEMS survey immediately. As a result of this acquisition plan, there is no requirement for any additional pre-start observations or for the Operational Area to be considered as a 'new location' given the acoustic source has been active within the TEMS Operational Area prior to commencing the survey.

2.1.7 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. With regard to soft starts, the following points are critical:

- **The operational source capacity (5,085 in^3) is not to be exceeded during the soft start period; and**
- **The observer team must draw this to the attention of the seismic staff on-board the vessel.**

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

2.1.8 Mitigation Zones for Delayed Starts and Shutdowns

The results of the sound transmission loss modelling (STLM) predicted that the sound exposure levels (SELs) from the 18SBB3D Seismic Survey could exceed the SEL thresholds outlined in the Code of Conduct. The SEL from the 5085 cu.in source array is predicted to meet the 171 dB re 1µPa^2·s threshold at a radius of 1.2 km. While TEMS could apply this 1.2 km mitigation zone for a single species of concern and still meet the mitigation requirements under the Code, the company has elected to extend the mitigation zone by 300 m to match that of mothers and calves. TEMS will solely use the larger 1.5 km mitigation zone throughout the 18SBB3D survey for all Species of Concern, regardless of whether they are accompanied by calves or not as described in **Section 2.2**.

For Other Marine Mammals, the standard 200 m mitigation zone will apply.

A summary of the mitigation zones that will be adopted for the 18SBB3D Seismic Survey is provided in **Section 2.2.1.**

2.1.9 Line turns

Activation of any seismic source solely for mitigation purposes during line turns is not supported by the Code of Conduct unless specific approval has been sought through the MMIA. The 18SBB3D Seismic Survey may run a system of 'continuous line acquisition', meaning that acquisition will continue throughout line turns to reduce the overall duration of the survey by up to 20%. This concept is in keeping with the objectives of the Code of Conduct as it serves to minimise noise in the marine environment and is not introducing any extra noise solely for mitigation purposes during line turns.

2.1.10 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.

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

2.1.11 Ground Truthing of Sound Transmission Loss Modelling

As per the Code of Conduct requirements, TEMS will conduct ground-truthing during the survey to verify the results of the STLM. In order to do this, representative data recorded on the seismic streamers during the seismic survey will be used to compare actual sound exposure levels with STLM predictions and to measure the SELs at each mitigation zone boundary.

The undertaking of this ground truthing is the responsibility of the on-board TEMS seismic data technicians; however, they may seek input from the qualified observers during this process with regards to understanding the mitigation zones and the acoustic thresholds outlined in the MMIA.

2.1.12 Key contacts and communication protocols

The key contact for DOC is Kris Ramm who can be contacted by phone on +64 27 201 3478 or email at kramm@doc.govt.nz. Kris is the primary point of contact for all DOC enquiries or notifications except for those regarding Maui's or Hector's dolphins (see additional contacts provided in **Section 2.2.2** below). Note that if Kris cannot be reached, DOC's secondary point of contact is Andrew Baxter (phone +64 3 546 3172, email abaxter@doc.govt.nz).

Any correspondence with the EPA should be directed to seismic.compliance@epa.govt.nz.

2.2 Variances or Additions to the Code of Conduct

This section outlines the agreed variances to the Code of Conduct or additional procedures above and beyond the Code of Conduct. These variances and additions have been adopted by TEMS for the purpose of the 18SBB3D Seismic Survey and agreed by DOC as part of the MMIA process. 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 18SBB3D Seismic Survey.

2.2.1 Mitigation Zones for Delayed Starts and Shutdowns

As the STLM results indicate the source may exceed the SEL thresholds defined in the Code of Conduct, TEMS has adopted a larger mitigation zone for Species of Concern during the 18SBB3D Seismic Survey as described below.

Species of Concern (with or without calves) within a mitigation zone of 1,500 m

If, during pre-start observations or while the acoustic source is activated (including during soft starts), a qualified observer detects at least one Species of Concern (with or without a calf) within 1,500 m of the source, start-up will be delayed or the source will be shut down and not reactivated until:

- A qualified observer confirms the group has moved to a point that is more than 1,500 m from the source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1,500 m of the source, and the mitigation zone remains clear.

Other Marine Mammals within a mitigation zone of 200 m

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

- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m from the source; or
- Despite continuous observation, 10 minutes has elapsed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m of the source, and the mitigation zone remains clear.

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

A summary of the mitigation zones that will be adopted for the 18SBB3D Seismic Survey is provided in **Appendix 3**, and the required mitigation actions are summarised in the 'Operational Flowchart' in **Appendix 4.**

2.2.2 Reporting Requirements

In addition to the reporting requirements outlined in **Section 2.1.5**, the following additional reporting components are required:

- Marine mammal sightings will be collected whilst in transit to the Operational 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 marine mammal entanglement incidents with seismic gear at the sea surface and will report any entanglement incidents immediately to DOC;
- MMOs will be vigilant for dead marine mammals observed at sea and will report details of these incidences to DOC in the final trip report;
- MMOs to notify DOC immediately of any Hector's/Maui's dolphin sightings. These sightings will be made via telephone to Callum Lilley on +64 27 206 5842, with a follow up email sent to clilley@doc.govt.nz; and
- Weekly MMO reports will be provided to DOC (Kris Ramm) and the EPA. Suggested headings for these reports are as follows:
  - Report Information (date and distribution list);
  - Summary of Operations (seismic operations, weather, observer effort);
  - Marine mammal detections (date, species, number, closest distance, array status);
  - Interruptions to seismic operations (shut downs, delayed starts);
  - Other notable fauna; e.g. turtles, threatened shark species, penguins etc. (date, species, number, closest distance, array status etc); and
  - Compliance issues (description of any compliance issues and method of address).
- Weekly reports should also note any streamer loss incidents during the survey.

2.2.3 Other

In addition to the four qualified observers, TEMS has committed to provide an opportunity for a trained iwi MMO on-board the seismic vessel during the 18SBB3D Seismic Survey. However, given the seismic vessel will be going straight from the Schlumberger Western Platform

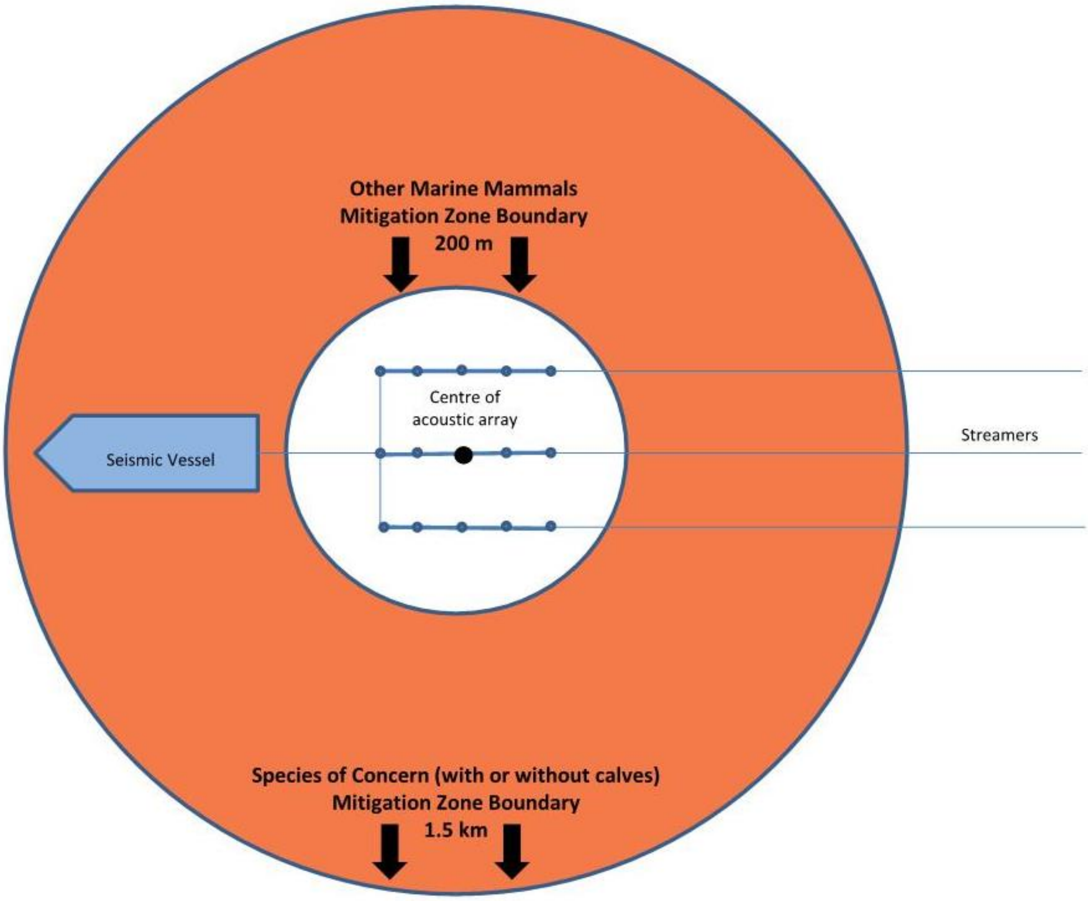
APPENDIX 1: COORDINATES OF THE 18SBB3D OPERATIONAL AREA

18SBB3D Operational Area	
NZTM_E	**NZTM_N**
1674260.0897	5582823.6580
1674658.7026	5584439.8523
1677137.3505	5585432.7609
1696524.4352	5585483.4935
1704344.4966	5573749.7776
1744923.2956	5573641.0649
1748815.2075	5572155.3257
1751069.1826	5570075.2909
1751409.8155	5558109.6546
1751011.2026	5555297.6214
1750040.0365	5554094.5350
1745698.7790	5553275.5666
1677601.1910	5553362.5367
1675738.5814	5554652.5932
1674318.0697	5557073.2610

APPENDIX 2: SPECIES OF CONCERN

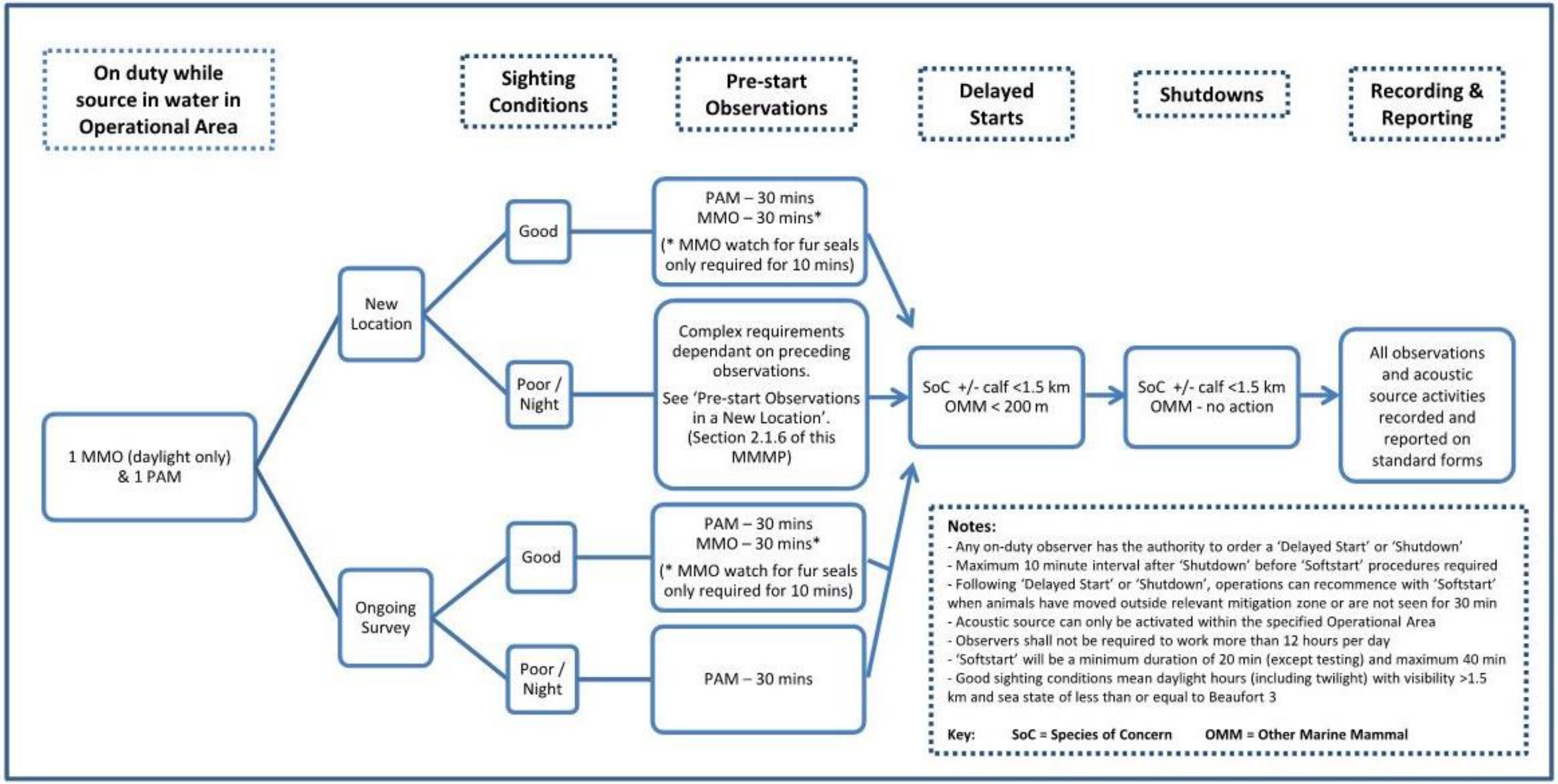
LATIN NAME	COMMON NAME
Megaptera novaeangliae	Humpback Whale
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Whale
Balaenoptera bonaerensis	Antarctic Minke Whale
Balaenoptera acutorostrata subsp.	Dwarf Minke Whale
Balaenoptera musculus	Blue Whale
Balaenoptera physalus	Fin Whale
Balaenoptera 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
Peponocephala 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 ginkgodens	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
Tursiops truncatus	Bottlenose Dolphin

APPENDIX 3: SUMMARY OF MITIGATION ZONES FOR THE 18SBB3D SEISMIC SURVEY



Adapted from the Code of Conduct (DOC, 2013)

APPENDIX 4: OPERATIONAL FLOWCHART



Adapted from the Code of Conduct (DOC, 2013)

APPENDIX D: Passive Acoustic Monitoring Specifications

PAM Specifications

Cetacean Detection Capability

The vocalisations made by the full range of marine mammal species can be detected by our PAM systems. Typical system configuration has the capability of detecting sounds within a frequency range of 200 Hz to 200 kHz. This frequency band covers most marine mammal vocalisations. The system sensitivity may be extended to 10 Hz to 200 kHz for surveys in which it is necessary to monitor for baleen whales that vocalise at very low frequencies. However, in some circumstances, vessel noise at low frequencies can mask marine mammal vocalisations and limit the performance of PAM. The frequency response of some hydrophone channels is set to counter this (e.g. lower frequency response of 2 kHz for channels designed to detect the majority of species vocalisations). Seiche can readily tailor the frequency sensitivity of the hardware to suit the project application and the range of marine mammal species likely to be encountered. Additionally, PAMGuard software can be configured to focus on the detection of the vocalisations of particular species of interest or concern.

PAMGuard Software

PAMGuard software is integrated into all our PAM systems. PAMGuard is industry-standard software for the acoustic detection, localization and classification of vocalizing marine mammals. It is a sophisticated and extendible software package that assists trained operators in robust decision-making during real-time mitigation operations. As an open source development, PAMGuard is publicly owned and freely available. PAMGuard development is led by a team of specialists at the University of St Andrews, U.K. This has to date been funded by industry via the IOGP Sound and Marine Life Joint Industry Program. Funding is now transitioning to a self-funding mechanism operated through voluntary user contributions.

Table 1. Hydrophone elements frequency range

Hydrophone Elements	
H1	10 Hz to 200 kHz (-3 dB points)
H2	10 Hz to 200 kHz (-3 dB points)
H3	2 Hz to 200 kHz (-3 dB points)
H4	2 Hz to 200 kHz (-3 dB points)

Table 2. Hydrophone sensitivity

Hydrophone sensitivity	
Broadband channel sensitivity	-166 dB re 1V/µPa (nominal)
Standard channel sensitivity	-157 dB re 1V/µPa (nominal)