global environmental solutions

The Western Platform Multi Client 3D Seismic Survey

Marine Mammal Impact Assessment

Report Number 740.10032-R02

23 November 2017

Schlumberger New Zealand Ltd
94 Paraite Road
New Plymouth 4373

Version: v1.0

The Western Platform Multi Client 3D 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
740.10032-R02-v1.0	23 November 2017			
740.10032-R02 -v0.2	14 November 2017			
740.10032-R01-v0.1	25 October 2017			

Executive Summary

Schlumberger New Zealand Ltd (Schlumberger) is proposing to acquire a three dimensional (3D) multi-client marine seismic survey in the Taranaki Basin. The 'Western Platform Multi-Client 3D Seismic Survey' is located off the west coast of central and southern North Island. The seismic survey is predicted to occur between December 2017 and March 2018 with an acoustic source volume of 5,085 in^3.

Under the Exclusive Economic Zone (Environmental Effects) Permitted Activities Regulations 2013, seismic operations in New Zealand's Exclusive Economic Zone (EEZ) must comply with the Department of Conservation's (DOC) 2013 *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the 'Code of Conduct'). 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 Schlumberger as a key part of the development of this MMIA.

Evaluations of the baseline environment of the Operational Area indicate that minke whales, bottlenose dolphins, dusky dolphins, false killer whales, killer whales, Gray'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. It is well 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 address both behavioural and physiological effects associated with acoustic disturbance.

Compliance with the Code of Conduct is the primary mitigation measure that will be employed during the Western Platform Multi-Client 3D Seismic Survey. The following specific actions are particularly important with regards to implementing the Code of Conduct:

- 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 when starting 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 operational power is reached; and
- The acoustic source will be shut down if marine mammals enter the defined mitigation zones.

Sound transmission loss modelling predicts how far sound emitted from the seismic survey is predicted to travel underwater, and is used to assess the validity of the 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 Western Platform Multi-Client 3D 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 for all 'Species of Concern' (with or without calves) throughout the Operational Area.

In addition to compliance with the Code of Conduct, Schlumberger have committed to the following actions to avoid, remedy or mitigate potential adverse effects on ecological, socio-economic and cultural components of the environment during the Western Platform Multi-Client 3D Seismic Survey:

Executive Summary

- Schlumberger has undertaken source modelling to ensure that their survey is using the lowest possible acoustic source volume while still ensuring the geological objectives of the survey can be fulfilled;
- 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 to notify DOC immediately of any Hector's/Maui's dolphin sightings;
- Weekly MMO reports to be provided to the regulators;
- Schlumberger will consider covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings;
- Schlumberger will operate 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;
- The seismic vessel will receive an iwi blessing before the survey commences;
- Iwi will be updated on any non-compliance issues that may arise during the survey;
- Post-survey engagement to be conducted to inform iwi and stakeholders of key survey outcomes; and
- Post-survey bathymetry information will be offered to stakeholder groups.

This MMIA identifies all potential environmental effects from the Western Platform Multi-Client 3D Seismic Survey and describes the 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 on marine mammal impacts, potential effects on other components of the marine ecosystem and existing maritime activities are also considered.

In summary, the predicted effects of the Western Platform Multi-Client 3D Seismic Survey are generally considered to be ***low to medium***, with medium effects representing a small environmental impact that is sufficiently managed by the mitigation measures that have been proposed. There is however a ***high*** risk of auditory masking of marine mammals (particularly blue whales in South Taranaki Bight); however the long acquisition lines will provide a period of relative relief from masking every 24 hours.

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

1.1 Background

Schlumberger New Zealand Ltd (Schlumberger) is proposing to acquire a three dimensional (3D) marine seismic survey in the Taranaki Basin. The Operational Area within which all seismic operations will be restricted is illustrated in **Figure 1**. The majority of seismic operations will occur in an area that runs from approximately 100 km offshore of Marokopa in the north to 180 km offshore of Himatangi Beach in the south. In the southern portion of the Operational Area a tie line will extend eastwards towards Patea. The purpose of this tie line is to correlate known logged data from down the well bore at the Kupe Field with contemporary data collected during the current survey. As illustrated in **Figure 1,** by far the majority of seismic operations will occur outside of the 12 nm Coastal Marine Area (CMA) (also known as the Territorial Sea); however there is a small overlap between the Operational Area and the CMA around Cape Egmont.

A Petroleum Prospecting Permit (PPP: permit no. 60409) has been issued by New Zealand Petroleum and Minerals, which surrounds the Operational Area and facilitates the prospecting activities. Schlumberger are planning to undertake this survey in Q4 of 2017, with a start date of 1 December 2017. It is anticipated that the survey could take up to three months to complete. However, the duration is dependant to some extent on down-time for weather and marine mammal encounters. A dedicated 3D seismic vessel, the *M/V Amazon Warrior* (**Figure 3**), will be used to undertake the Western Platform Multi-Client 3D Seismic Survey.

Under Section 23 of the Crown Minerals Act 1991, the purpose of a PPP is to authorise the holder to undertake activities for the purpose of identifying petroleum deposits through geological or geophysical surveying. Further details in regard to the Crown Minerals Act are provided in **Section 3.1**.

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

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 Western Platform Multi-Client 3D Seismic Survey. The MMIA also sets out the measures that will be employed to avoid, remedy or mitigate any potential environmental effects.

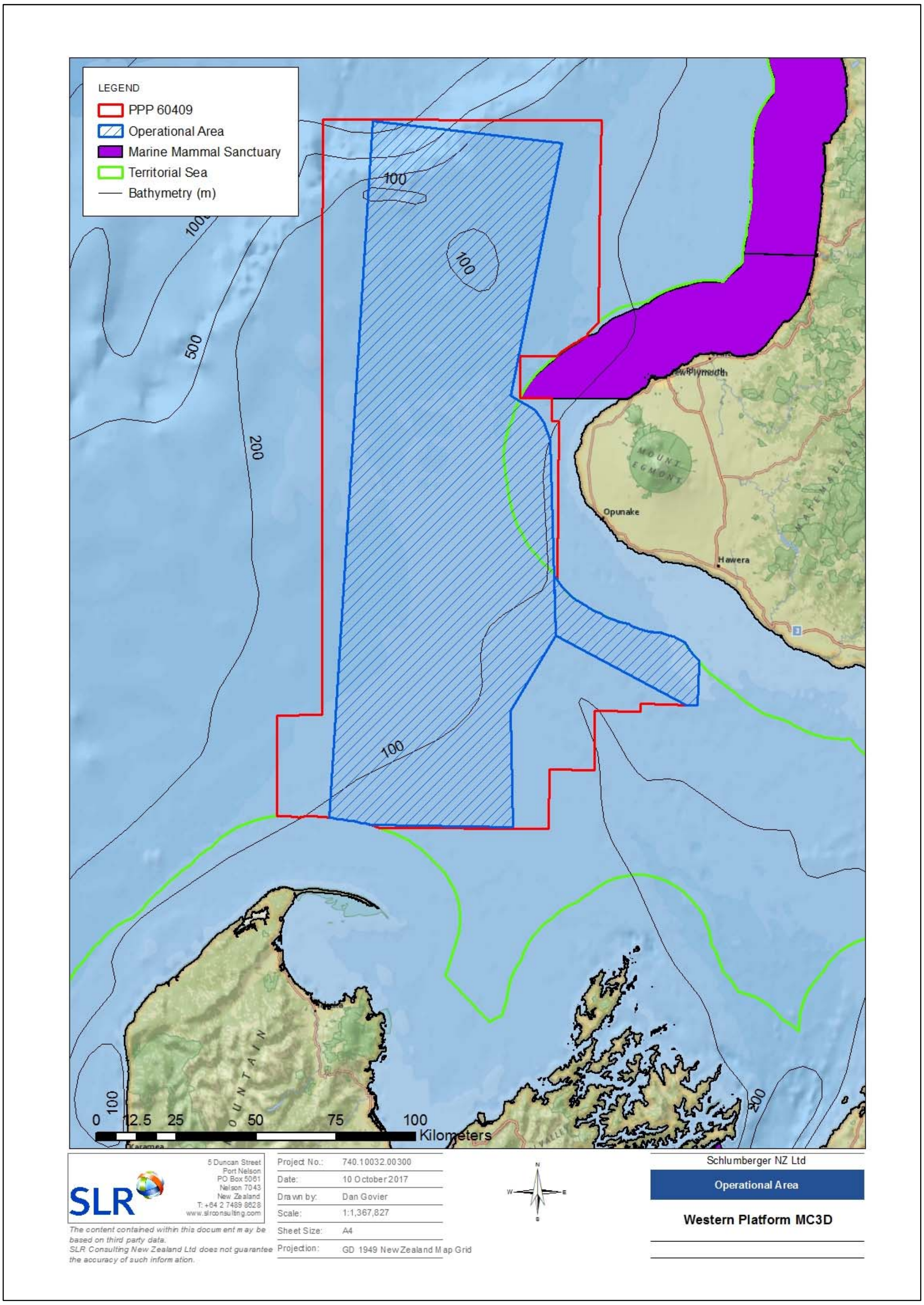
1.2 General Approach

This MMIA is an integral component to ensure Schlumberger undertakes the Western Platform Multi-Client 3D Seismic Survey in adherence to the EEZ Act (permitted activities regulations) and the Department of Conservation (DOC) Code of Conduct. As well as operating to the requirements of the Code of Conduct throughout their entire Operational Area, Schlumberger will operate in accordance with relevant New Zealand legislation, international conventions and their internal environmental standards.

The Western Platform Multi-Client 3D Seismic Survey is classified as a 'Level 1 Survey' by the Code of Conduct and Schlumberger will comply with the relevant requirements while conducting their survey. The Code of Conduct requirements of a Level 1 marine seismic survey are outlined in **Section 3.5**. **Section 7** outlines all measures that Schlumberger 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 the Western Platform Multi-Client 3D Seismic Survey MMIA, an extensive review of literature and existing data on the environment surrounding the Operational Area has been undertaken (see **Section 4**). A full list of references is presented in **Section 9**.

Figure 1 Location of Western Platform Multi-Client 3D Seismic Survey Operational Area



2 PROJECT DESCRIPTION

2.1 Marine Seismic Surveys - overview

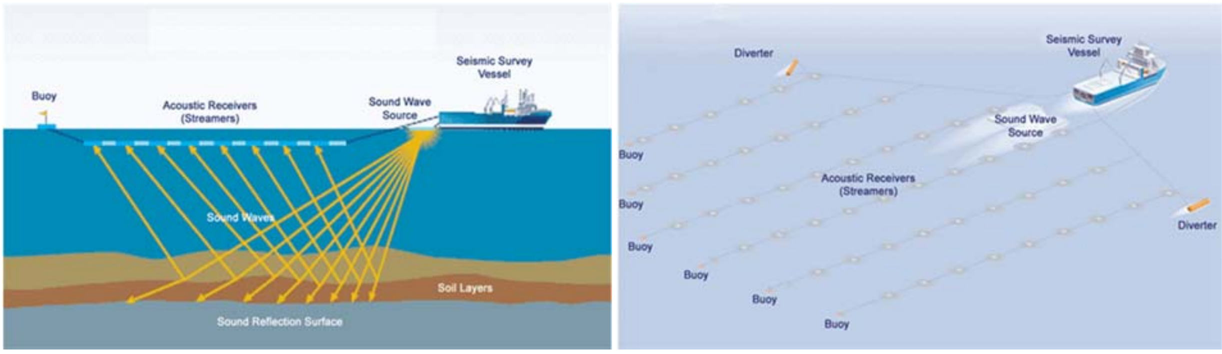
The basic principle behind a marine seismic survey is that an energy source (i.e. acoustic source) instantaneously releases compressed air, releasing a directionally focused acoustic wave at low frequency that travels several kilometres through the earth. As the acoustic wave travels through the earth, portions 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 fairly basic survey method which involves a single source and a single streamer towed behind the seismic vessel (**Figure 2**). In contrast, a 3D survey is a more complex method which involves a greater span of equipment to provide a more complex image of the earth's strata (**Figure 2**).

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

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.
- The frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in Hertz (Hz), or cycles per second.

Sound levels in water are not the same as sound levels in air and confusion often arises when trying to compare the two. The reference level of the amplitude of a sound must always be specified. For sounds in water the reference level is expressed as 'dB re 1µPa' – the amplitude of a sound wave's loudness with a pressure of 1 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

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). Source levels range from ~222 – 264 dB when measured relative to a reference pressure of one micro-pascal (re 1µPa-$m_{p\text{-}p}$) (Richardson et al., 1995). However, the overall amplitude depends on how many elements are in each array; there are typically two identical arrays that are activated alternatively during a seismic survey.

2.1.4 The streamers

When the acoustic source is activated, the hydrophones in the streamers detect the sound wave that is reflected back up 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 bandwidth of received data. Typical streamer operating depths range from 4 – 5 m for shallow high resolution surveys in relatively good weather, to 8 – 12 m for deeper penetration and lower frequency targets in more open waters.

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 of the streamers.

2.2 Western Platform Multi-Client 3D Seismic Survey

The Western Platform Multi-Client 3D Seismic Survey is located off the west coast of central and southern North Island (**Figure 1**), where the southern portion of the Operational Area approaches the north coast of the South Island near Farewell Spit and extends eastwards towards Patea. Water depths within the Operational Area range from approximately 30 to 1,000 m.

Schlumberger has been involved in a number of seismic projects in the Taranaki Basin over the last few years. Existing seismic data from the proposed Operational Area is insufficient to provide an accurate subsurface image in this geologically complex area; hence the acquisition of modern broadband 3D seismic data, with a high-resolution velocity model is required to make estimates on prospect sizes and structural closures here. The Western Platform Multi Client 3D Seismic Survey will provide a new level of geological understanding in the area and will significantly reduce exploration risk associated with structural uncertainty.

The seismic vessel, the *M/V Amazon Warrior* (**Figure 3**) will be used to undertake the survey. Seismic survey parameters are summarised in **Table 2** and discussed below.

During the Western Platform Multi-Client 3D Seismic Survey, the *M/V Amazon Warrior* will tow 14 solid streamers (Q-Marine Solid™) of approximately 8 km in length. 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 robust and resistant to damage (e.g. shark bites), they require less frequent repairs, and they are steerable, allowing greater control of the streamers, resulting in less infill lines and a reduction in the cumulative sound energy introduced into the marine environment. During the survey, the seismic survey vessel will be travelling between four and five knots.

The acoustic source will be comprised of three sub-arrays, with an effective volume of 5,085 in^3. Eight acoustic sources are located on each of the sub-arrays. The acoustic arrays will be towed at a depth of 7.5 m below the sea surface. The acoustic source will have an operating pressure of 2,000 psi and will be fired at a source-point interval of 25 m. For a typical vessel speed of 4.5 knots, this equates to source activation every 10.8 seconds. The survey specifications are provided in **Table 3**.

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 Western Platform Multi-Client 3D Seismic Survey will run a system of 'continuous line acquisition', by shortening the lines and acquiring data during the turns Schlumberger can optimise vessel use and reduce the overall duration of the survey by approximately 20 %. The survey lines will run north-south and because of the length of the Operational Area, each line will take approximately 24 hours to acquire.

Schlumberger are planning to carry out the proposed Taranaki operations in Q4 of 2017, starting on 1 December. Subject to weather conditions and marine mammal shut-downs, the survey operations will be conducted 24 hours per day, 7 days per week. Seismic survey operations are expected to take up to three months to complete.

The *M/V Amazon Warrior* will be accompanied by a support vessel and a chase vessel. 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 Western Platform Multi-Client 3D Seismic Survey to ensure there are no vessels or objects in front of the survey vessel whilst acquiring.

Refuelling of the seismic vessel will be required approximately every five weeks during the survey. Refuelling will occur at sea, and mitigations around this are discussed in **Section 6.3.3.**

Survey operations can be divided into four main components:

- Mobilisation of seismic vessel to Operational Area (either from Nelson or New Plymouth);
- Deployment of acoustic equipment: Streamer and array deployment is expected to take up to three days. Once deployed the Marine Mammal Observers (MMOs) will begin pre-start observations as required under the Code of Conduct when arriving at a new location (**Section 3.5.6**), followed by a soft start;
- Data Acquisition: Once full acquisition is underway, the two MMOs and two Passive Acoustic Monitoring (PAM) operators will maintain watch for marine mammals (see **Section 3.5.4**); and
- Demobilisation: Once acquisition is complete, the seismic array and streamers will be retrieved and the vessel will head to its next destination.

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

Table 2 ***M/V Amazon Warrior* Technical Specifications**

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

Figure 3 **Seismic Vessel – *M/V Amazon Warrior***

Table 3 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

2.3 Navigational Safety

During the Western Platform Multi-Client 3D 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. COLREGS is implemented in New Zealand waters under the Maritime Transport Act 1994. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the presence of the seismic vessel in the Operational Area and the vessel's restriction in ability to manoeuvre while the streamers are deployed. The 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.

2.4 Survey design considerations

The majority of seismic surveys conducted worldwide use acoustic sources as they generate low frequency signals allowing the formation of images of the underlying geology below the seafloor. Schlumberger will use a Boltgun source array for the Western Platform Multi-Client 3D Seismic Survey, with the acoustic source consisting of three sub-arrays.

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

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

The initial Operational Area that Schlumberger developed for this survey entered the West Coast North Island Marine Mammal Sanctuary. However following discussions with SLR during the survey design phase, this overlap was removed to mitigate against any potential behavioural impacts on marine mammals (particularly Maui's dolphins) within the sanctuary. The alteration to the Operational Area (initial and revised) is illustrated in **Figure 4**.

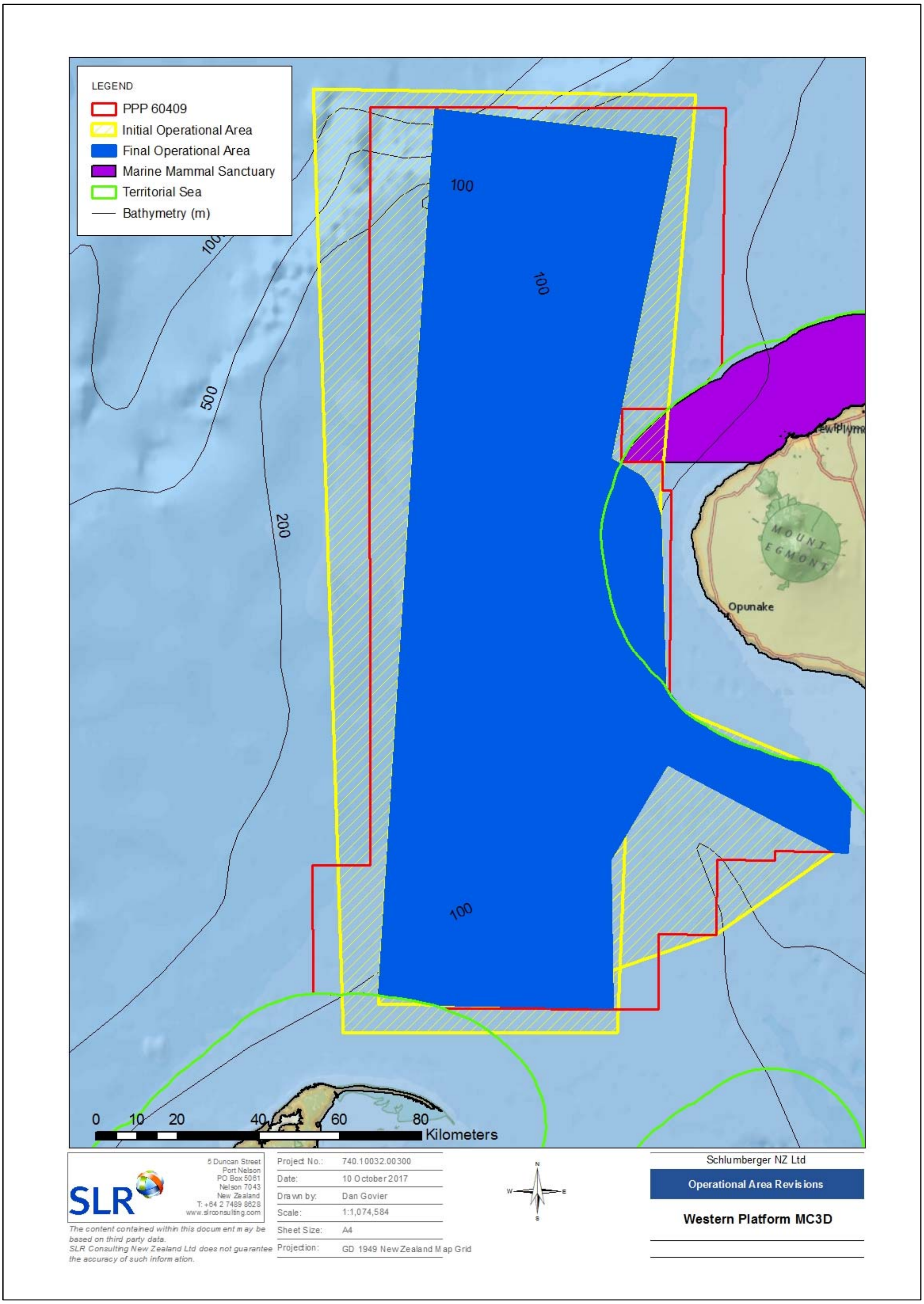
During engagement, additional concerns were raised about operations in the vicinity of the West Coast North Island Marine Mammal Sanctuary. Based on these concerns, further analysis was undertaken to determine the distance between the closest survey line (which sits inside the Operational Area) and the sanctuary boundary and to compare this to the STLM results (as discussed in **Section 6.2.2.1**). This analysis concluded that the closest survey line is 8.5 km from the sanctuary boundary and given that the STLM results indicate that behavioural effects would only be expected from animals within a 1.5 km radius of the acoustic source, no acoustic disturbance effects are expected within the sanctuary. On this basis, no additional mitigations are warranted.

In addition, seismic operations will be undertaken during the summer months in order to take advantage of settled summer weather. This intended timing not only makes for more amenable working conditions for crew, but also serves to reduce environmental impacts in the following ways:

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

Conversely, the intended timing also increases the potential environmental effects on blue whales feeding in the Operational Area over summer months.

Figure 4 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 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 Western Platform Multi-Client 3D Seismic Survey is described below.

3.1 Crown Minerals Act 1991

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

The Crown Minerals Act regime comprises the Crown Minerals Act 1991, two minerals programmes (one for petroleum and one for other Crown-owned minerals), and associated regulations. Together, these regulate the exploration and production of Crown-owned minerals (NZP&M, 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 Western Platform Multi-Client 3D Seismic Survey.

3.2 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 Nm, 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 Western Platform Multi-Client 3D Seismic Survey overlaps with the CMA off Cape Egmont (**Figure 1**) and although the Code of Conduct is voluntary within the CMA (and is neither legally binding nor enforceable), Schlumberger will comply with the Code of Conduct throughout their entire Operational Area as it represents environmental best practice. Compliance with the Code of Conduct presumably satisfies section 16 of the RMA.

In addition, the Taranaki Regional Coastal Plan (1997) states that seismic surveys are a permitted activity in the coastal marine area provided:

- 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.

With regards to the conditions above, and in relation to the small area of overlap between the Operational Area and the territorial sea (off Cape Egmont), the Western Platform Multi-Client 3D Seismic Survey is not predicted to overlap with significant breeding habitat for marine wildlife. The two species of note with regards to breeding in the Cape Egmont vicinity during summer months are Maui's dolphins and New Zealand fur seals. The population concentration for Maui's dolphins is well north of Cape Egmont and most sightings occur within 4 nm of the coastline (Du Fresne, 2010), and for this reason it is considered that the potential for spatial overlap between the Western Platform Multi-Client 3D Seismic Survey and critical breeding behaviours of Maui's dolphins are limited. The closest breeding colony of New Zealand fur seals is the Sugar Loaf Islands, some 40 km away. Even though pups are born over summer, they remain at their terrestrial breeding colony for 8 – 12 months until they are weaned (Baird, 2011); hence pups will be protected from any acoustic disturbance from the seismic survey. In addition, no explosives will be used during the Western Platform Multi-Client 3D Seismic Survey.

It is worth noting here that the Taranaki Regional Coastal Plan is currently under review. The new draft plan proposes that seismic surveys within the CMA be considered permitted activities as long as they comply with the Code of Conduct. It is likely that this draft will become effective in early 2018.

3.3 Marine Mammals Protection Act 1978

DOC administers and manages all Marine Mammal Sanctuaries in accordance with the Marine Mammals Protection Act 1978 (and associated general policy). Marine Mammal Sanctuaries are established to provide protection of marine mammals from harmful human impacts, particularly in sensitive areas such as breeding grounds, migratory routes and the habitats of threatened species. There are currently 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 proposed Operational Area of the Western Platform Multi-Client 3D Seismic Survey approaches to within approximately 3 km of the West Coast North Island Marine Mammal Sanctuary; however, no acquisition will occur within the sanctuary itself and the closest survey line is 8.5 km away. A full description of the sanctuary can be found in **Section 5.3.2**.

3.4 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.

Based on considerations such as effects on the environment or existing interests, protection of rare and vulnerable ecosystems and economic benefit to New Zealand, 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 60 working days in which to process the application;
- **Discretionary** – the activity may be undertaken if the applicant obtains a marine consent from the EPA. The consent application will be notified, submissions will be invited and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 140 working days in which the EPA must assess the consent application; and
- **Prohibited** – the activity may not be undertaken.

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

3.5 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 Taranaki 3D Multi-Client Seismic Survey is classified as a Level 1 survey. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

3.5.1 Notification

The notification requirements of the Code of Conduct have been adhered to and following with the formulation of this MMIA. A letter was submitted to the Director-General of Conservation by Schlumberger on 1 August 2017 to notify DOC of their intention to carry out the Western Platform Multi-Client 3D Seismic Survey.

3.5.2 Marine Mammal Impact Assessment

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

- Describe the activities related to the survey;

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

3.5.3 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.

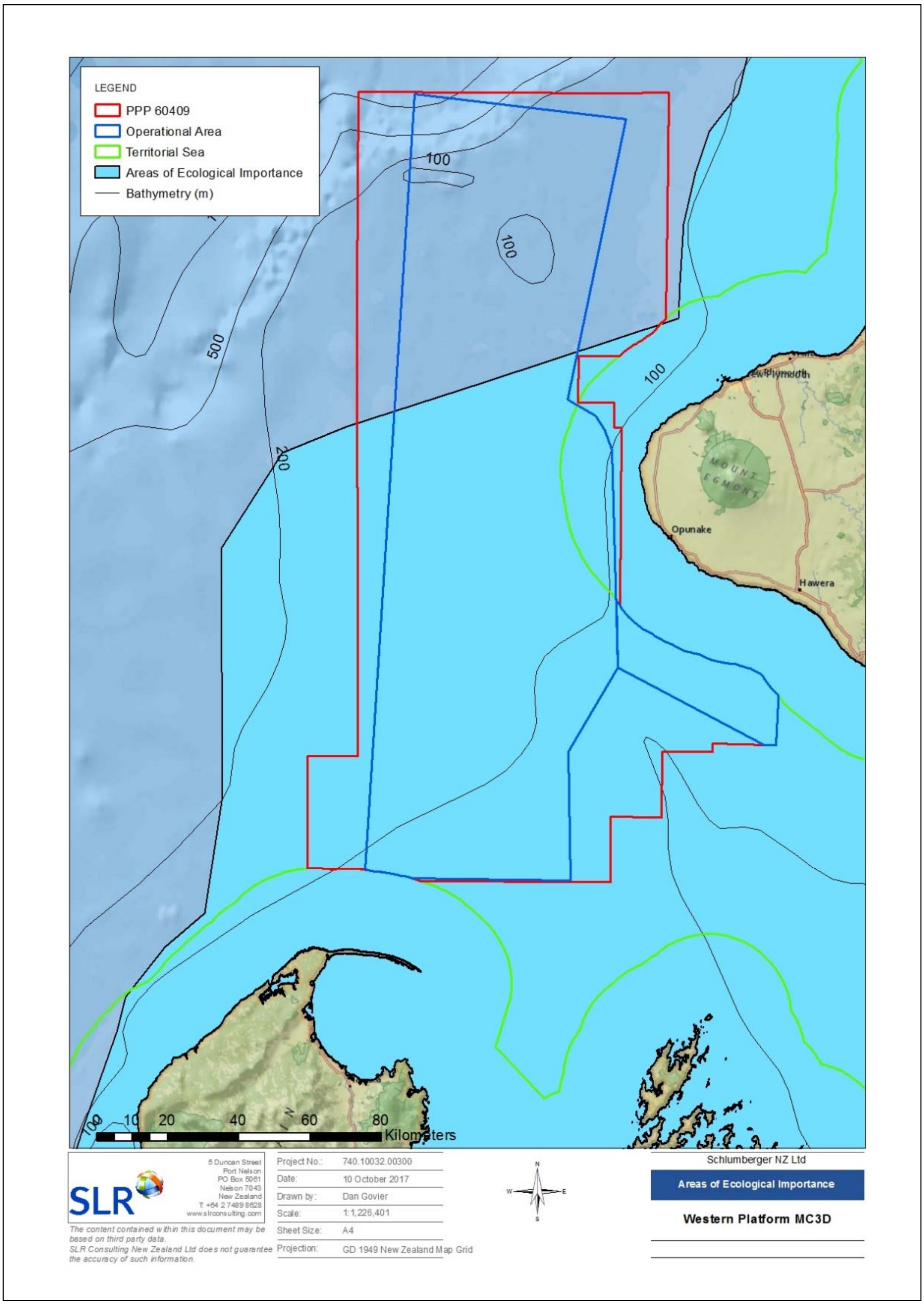
The Western Platform Multi-Client 3D Seismic Survey will largely occur within the Area of Ecological Importance (**Figure 5**). A summary of measures that Schlumberger will implement to offset this are identified in **Section 7**.

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 behavioural and physiological impacts during the seismic survey in accordance with the following thresholds:

- The behavioural threshold is exceeded if marine mammals are subject to Sound Exposure Levels (SELs) greater than 171 dB re 1μPa2.s; and
- The physiology threshold is exceeded if marine mammals are subject to SELs greater than 186 dB re 1μPa2.s (also known as the injury threshold).

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 Western Platform Multi-Client 3D Seismic Survey STLM are discussed in **Section 6.2.2.1**.

Figure 5 Relationship between the Operational Area and Areas of Ecological Importance



3.5.4 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.

3.5.5 Operational and Reporting Requirements

MMOs and PAM operators are required under the Code of Conduct to record and report all marine mammal sightings during the survey. All raw datasheets must be submitted directly to DOC 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 4**.

Table 4 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.
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

3.5.6 Pre-start Observations

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

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

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

- MMOs have undertaken observations within 20 Nm of the planned start up position for at least the last two hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than two hours of good sighting conditions preceding proposed operations (within 20 Nm of the planned start up position), the source may be activated if:
  - PAM monitoring has been conducted for two hours immediately preceding proposed operations;
  - Two MMOs have conducted visual monitoring in the two hours immediately preceding proposed operations;
  - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the two hours immediately preceding proposed operations;
  - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed operations; and
  - No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

3.5.7 Soft Starts

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

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

3.5.8 Delayed Starts and Shutdowns

The Western Platform Multi-Client 3D Seismic Survey will require deviations from the standard Code of Conduct requirements with regards to delayed starts and shut downs. These are 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 is insufficient to protect marine mammals (without calf) from behavioural disturbance during the Western Platform Multi-Client 3D Seismic Survey. For this reason, larger mitigation zones have been adopted for Species of Concern as follows.

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 1.5 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 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.

4 ENGAGEMENT

Schlumberger has undertaken engagement with existing interests, stakeholders, and tangata whenua in relation to the Western Platform Multi-Client 3D Seismic Survey. These groups were identified based on the geographical extent of underwater noise propagation in discussion with DOC. This engagement process involved groups being engaged with either in person or via email. All groups that were contacted or met with are listed in **Table 5.**

Table 5 Groups with which engagement has occurred

Iwi	
Ngati Mutunga	Taranaki Iwi
Te Atiawa Trust	Nga Ruahine
Te Atiawa (Taranaki) - Ngati Rahiri	Ngati Ruanui
Te Atiawa (Taranaki) - Manukorihi	Nga Rauru Kitahi
Te Atiawa (Taranaki) - Otaraua	Manawhenua ki Mohua
Other	
Department of Conservation - Wellington	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	Oregon State University
Egmont Seafoods	Forest & Bird
Auckland University	Project Jonah

Engagement meetings were also offered to Ngati Tama and Ngati Maniapoto; however, these groups were unavailable to meet.

The information sheet provided in **Appendix B** formed the basis of the engagement process. A register outlining the key points of the formal engagements is included as **Appendix C**.

The primary commitments made by Schlumberger 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);
- Iwi MMOs and PAM operators will be provided with employment opportunities during the survey. A list of seven potential iwi MMOs (Ngati Mutunga x1, Te Atiawa x3, Taranaki Iwi x1, Ngati Ruanui x2) was provided to Schlumberger during the engagement process (However, the MMO providers will be engaging iwi MMOs for the survey);
- The *M/V Amazon Warrior* will receive an iwi blessing before the survey commences;
- Iwi will be updated on any non-compliance issues that may arise during the survey;
- Post-survey engagement to be conducted to inform stakeholders and iwi of key survey outcomes; and
- Post-survey bathymetry information was offered to stakeholder groups.

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 bring a cold front 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 is exposed to intense weather systems from the Tasman Sea where Taranaki is one of the windiest regions in New Zealand (Chappell, 2014). In the offshore Taranaki environment the strongest and 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.

New Plymouth weather conditions have been used as indicative for the Operational Area. Mean monthly weather parameters at New Plymouth are shown in **Table 6**.

Table 6 Mean Monthly Weather Parameters at New Plymouth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	54	83	68	104	112	123	110	101	105	117	102	106
Temp – Avg. daytime (°C)	21	22	20	18	16	14	13	13	14	16	17	19
Temp –avg. night time (°C)	14	14	13	11	10	8	7	7	8	10	10	14
Avg. wind speed (kts)	17	17	17	16	18	19	18	18	20	22	20	18
Max. wind speed (kts)	56	70	56	61	65	69	67	57	87	107	57	69

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.

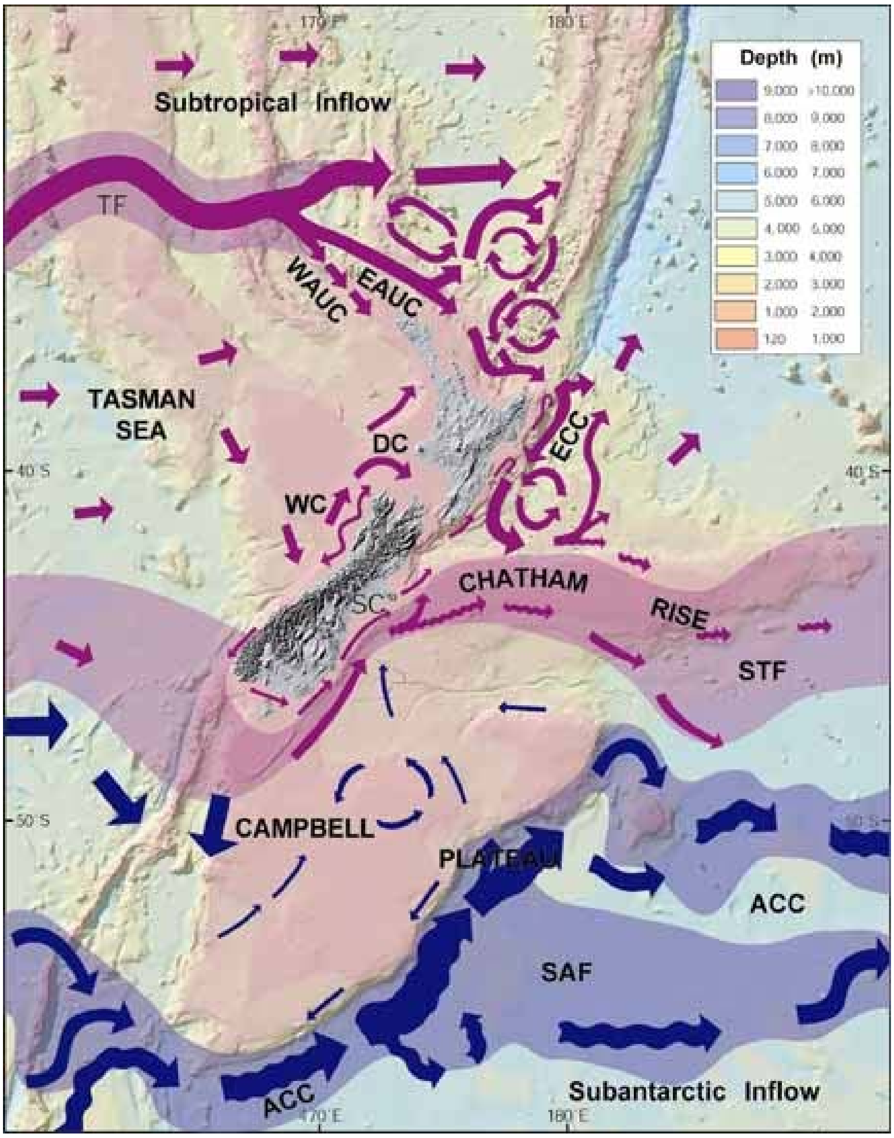
New Zealand lies in the pathway of eastward-flowing currents driven by winds blowing across the South Pacific Ocean (Brodie, 1960). This results in New Zealand being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the Roaring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

The primary ocean currents are illustrated in **Figure 6**. The eastward flow out of the Tasman Sea splits into two currents across the top of the North Island; the West Auckland Current flowing from Cape Reinga towards Kaipara, and the East Auckland Current flowing from North Cape towards the Bay of Plenty (Brodie, 1960; Heath, 1985; Stanton, 1973). As the West Auckland Current progresses south, it is met in the North Taranaki Bight by the north-flowing Westland Current. 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).

In the Operational Area currents are predominately influenced by the D'Urville and Westland Currents in the south, and the West Auckland Current in the north. Measurements of current speed and direction within the Operational Area are available for both the Māui and Tui Oil Fields; however, it is important to note that the current measurements at Māui and Tui represent surface current and depth averaged current speed respectively and are therefore not directly comparable. Although variable between months, surface currents within the Māui Field predominantly flow towards the north and south-southeast, with average surface current speeds of 0.24 ms-1 (maximum 1.44 ms-1) (RPS, 2014). The Tui Oil Field lies further north in the Operational Area than Māui and experiences strong depth averaged currents from the north and south-southwest, with little seasonal variation (MetOcean Solutions, 2013). Tidal currents on the Continental Shelf around Taranaki have been reported at speeds of approximately 0.07 ms^{-1}, with internal tides generating currents up to 0.3 ms^{-1} along the shelf edge (Orpin, 2015).

Figure 6 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 North 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 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). The largest waves are found off the western end of Cape Egmont, with wave height decreasing further south as a result of increasing shelter from prevailing south-westerly swells (MacDiarmid et al., 2015). Significant wave heights in excess of 8 m can occur during stormy conditions, particularly in the winter and early spring (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).

Table 7 outlines the average sea surface temperatures at the Tui Oil Field as summarised in MetOcean Solutions (2013). These are indicative of temperatures expected in the Operational Area.

Table 7 Average Sea Surface Temperature at the Tui Oil Field

Season	Average Temp (°C)
Summer	17.35
Autumn	17.53
Winter	14.37
Spring	14.49

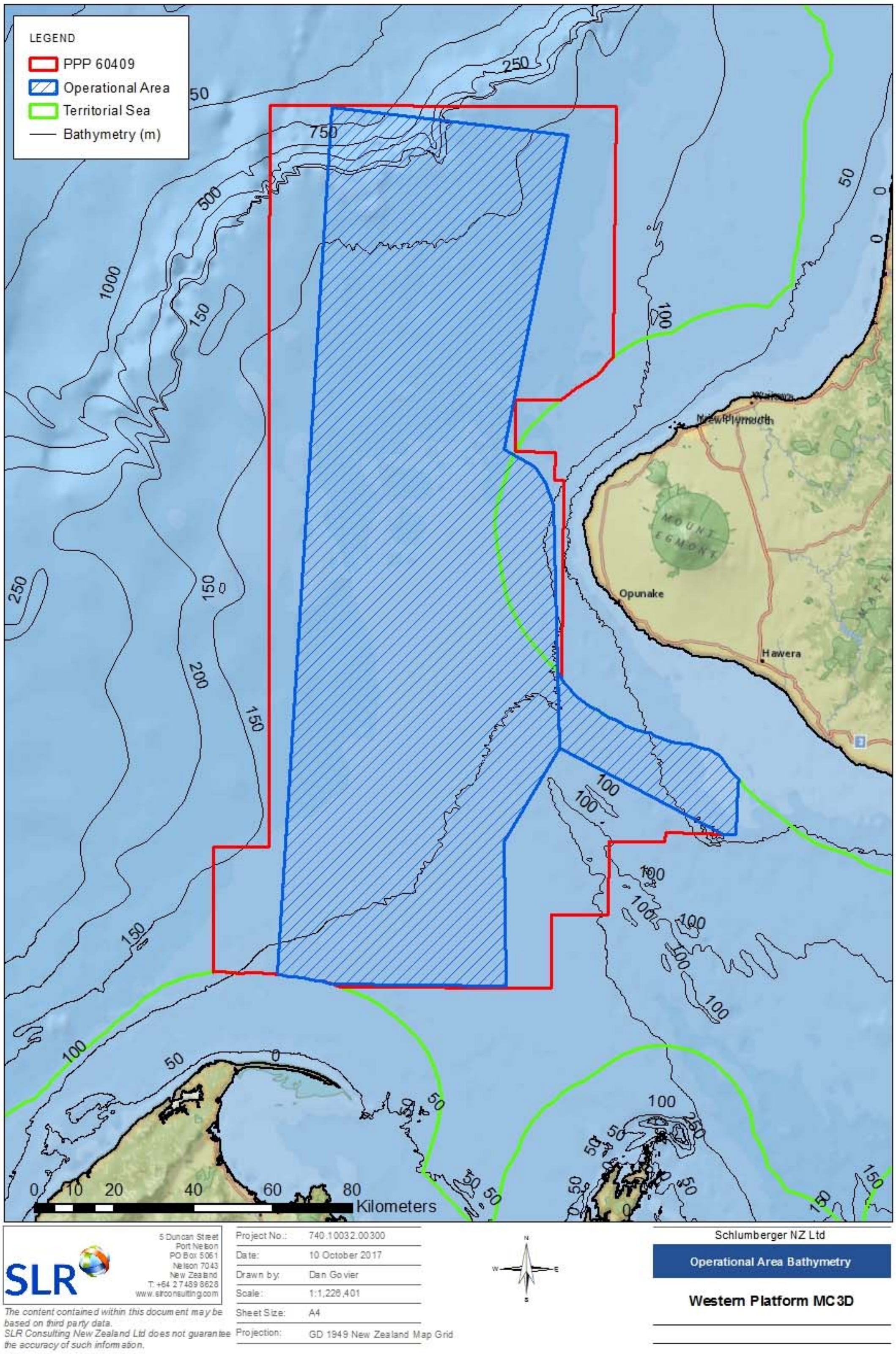
5.1.4 Bathymetry and Geology

New Zealand is surrounded by a flat, gently sloping zone; the continental shelf. The shelf extends form 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 form 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 7** and covers a range of water depths from the shallows off Patea (30 m) to the deeper offshore waters at the northwest boundary of the Operational Area (approximately 1,000 m).

Figure 7 Bathymetry of the Operational Area



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

Figure 8 New Zealand's Sedimentary Basins

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

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).

5.2 Biological Environment

5.2.1 Cetaceans

Both toothed whales (suborder Odontoceti) and baleen whales (suborder Mysticeti) comprise the 48 cetacean species that have been recorded in New Zealand waters (Baker et al., 2016). As the name suggests, toothed whales have teeth and hunt larger marine prey (primarily fish and cephalopods). In order to locate prey (and navigate) odontocetes use echolocation. Baleen whales on the other hand don't echolocate, but feed by using plates of baleen in their upper jaw as a sieve to filter plankton from the water column. Bothe toothed whales and baleen whales rely heavily on sound for communication and navigation; hence are vulnerable to the effects of anthropogenic noise.

The section below summarises which cetacean species could be present in the Operational Area. In addition, the potential impacts of the Western Platform Multi-Client 3D Seismic Survey are described in **Section 6** along with the measures proposed by Schlumberger to avoid, remedy or mitigate the effects of the survey on those cetaceans that may be present.

5.2.1.1 Cetacean species that could be present in the Operational Area

As ecological research on cetaceans is notoriously difficult and expensive (largely due to their large home ranges and extended periods of time spent submerged), knowledge of cetacean distribution is typically amassed 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 assess multiple data sources when considering cetacean distribution in any one location. This approach has been used in this section to assess which cetacean species may be present within the Operational Area. Data sources for this assessment include:

- Sightings data:
  - from previous seismic surveys (obtained from the DOC marine mammals sightings database);
  - from opportunistic sightings (obtained from the DOC marine mammals sightings database);
- Stranding data (obtained from the DOC marine mammals strandings database); and
- Knowledge of migration paths and habitat preferences of each species (obtained from published literature).

Despite these data sources representing the best possible information, it is important to exercise some caution as 1) data gaps in sighting data do not necessarily indicate an absence of cetaceans, but more likely a lack of observation effort; and 2) although stranding data gives a broad indication of species occurrence, it should be noted that dead animals can wash ashore a long way from where they died; and that prior to death, sick or diseased animals may be well outside their normal distributional range.

This MMIA aims to provide a broad overview of cetaceans which could be present in the Operational Area. It is noteworthy that data collected during the Western Platform Multi-Client 3D Seismic Survey will make a valuable contribution towards better understanding the distribution of cetaceans in these waters.

Figure 9 provides a summary of all sightings from the DOC marine mammal sightings database in the vicinity of the Operational Area, while **Figure 10** provides a summary of the DOC stranding records in the vicinity of the Operational Area.

The criteria used to assess the likelihood of a species being present in the Operational Area are presented in **Table 8**.

Table 8 Criteria 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 criteria 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.*

The findings of our assessment are summarised in **Table 9**, and a basic ecological summary for those more commonly occurring species is provided in the sections below.

Figure 9 Cetacean Sightings in the Vicinity of the Operational Area

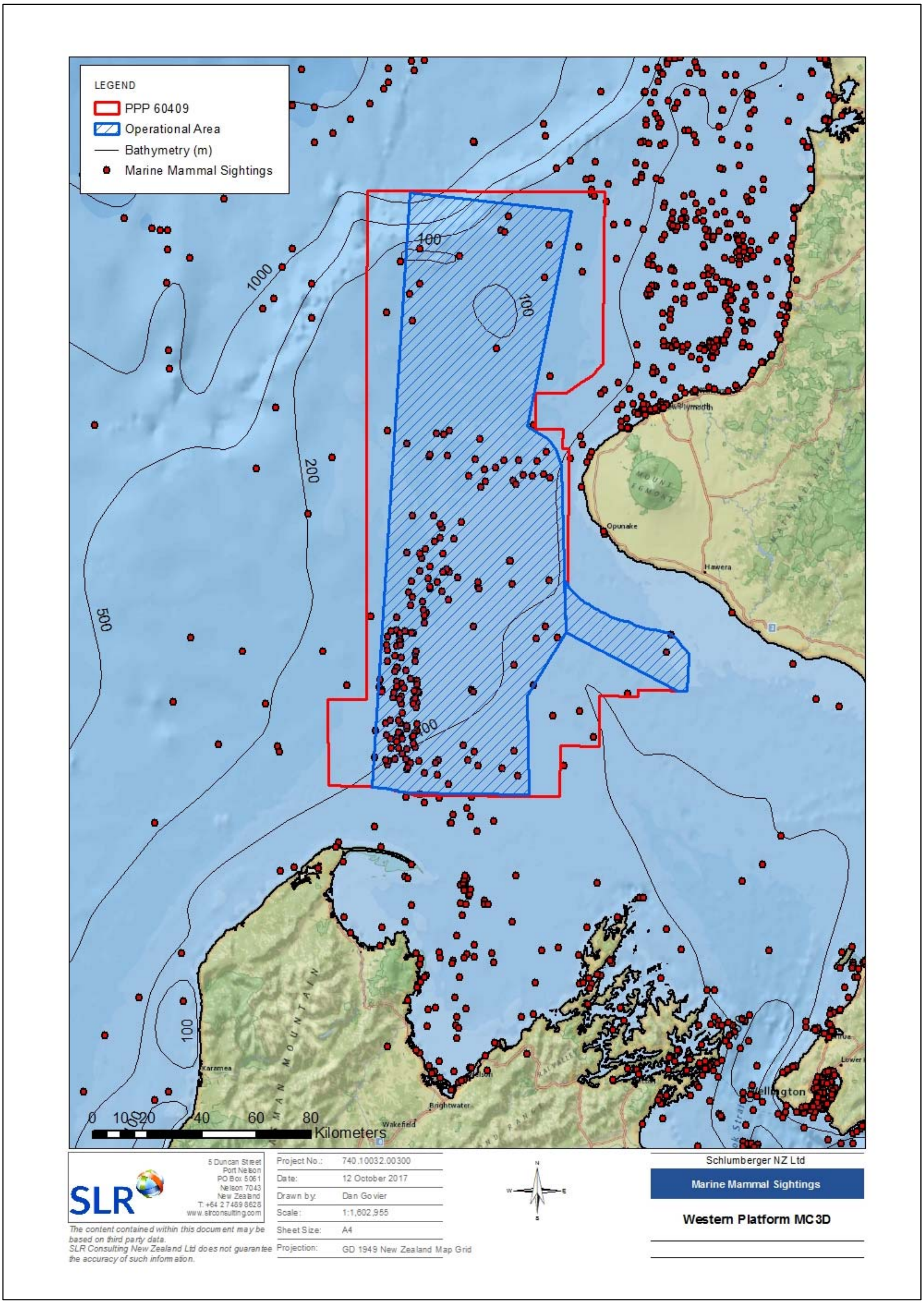


Figure 10 Cetacean Strandings in the Vicinity of the Operational Area

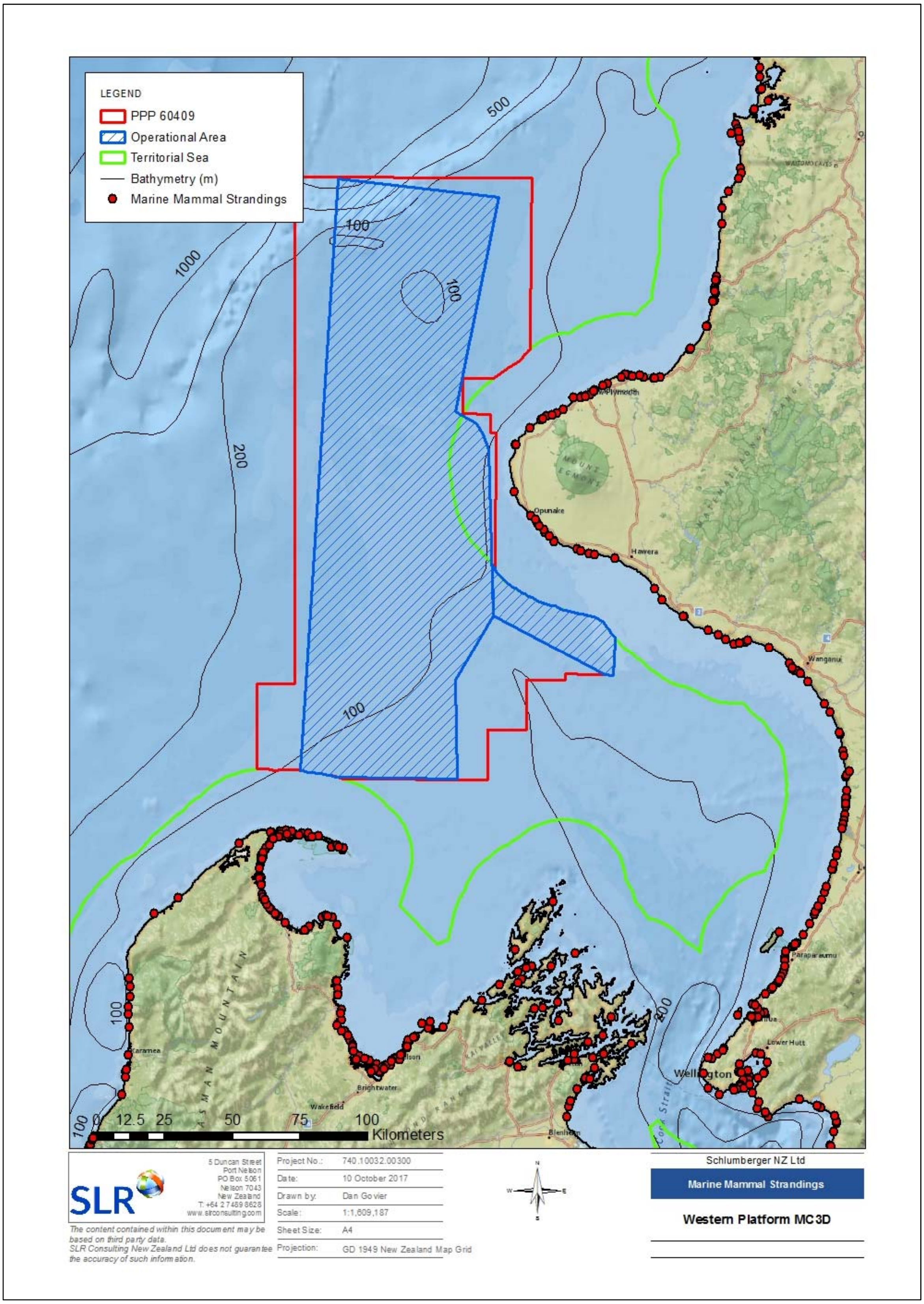


Table 9 Likelihood of Occurrence of Marine Mammals in the Operational Area

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	✓ (4)	×	Possible
Antarctic blue whale	*Balaenoptera musculus intermedia*	Migrant	TO	Critically endangered	Yes	✓ (5)	✓ (****)	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	✓ (2)	×	**Likely**
Arnoux's beaked whale	*Berardius arnuxii*	Migrant	SO	Data deficient	Yes	✓ (6)	×	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	✓ (16)	✓ (1)	**Likely**
Bryde's whale	*Balaenoptera edeni*	Nationally critical	SO	Data deficient	Yes	✓ (2)	✓ (2)	Possible ***
Common dolphin	*Delphinus delphis*	Not threatened	DP,SO	Least concern	No	✓ (77)	✓ (41)	**Likely**
Crab eater seal	*Lobodon carcinophaga*	Vagrant	SO	Least concern	No	×	×	Unlikely
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	SO	Least concern	Yes	✓ (20)	✓ (1)	Likely ***
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	SO	Data deficient	No	✓ (32)	✓ (2)	**Likely**
Dwarf minke whale	*Balaenoptera acutorostrata*	Not threatened	DP, SO	Least concern	Yes	✓ (12)	×	**Likely**
Dwarf sperm whale	*Kogia sima*	Vagrant	SO	Data deficient	Yes	×	×	Unlikely
False killer whale	*Pseudorca crassidens*	Not threatened	DP, SO	Data deficient	Yes	✓ (3)	✓ (1)	**Likely**
Fin whale	*Balaenoptera physalus*	Migrant	TO	Endangered	Yes	✓ (4)	✓ (3)	Occasional visitor
Fraser's dolphin	*Lagenodelphis hosei*	Vagrant	SO	Least concern	No	×	×	Unlikely
Gingko-toothed whale	*Mesoplodon ginkgodens*	Vagrant	SO	Data deficient	Yes	✓ (3)	×	Rare visitor
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	DP, SO	Data deficient	Yes	✓ (36)	×	**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	✓ (14)	✓ (2)	Possible ***
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	SO	Least concern	No	×	×	Unlikely
Humpback whale	*Megaptera novaeangliae*	Migrant	SO	Least concern	Yes	✓ (5)	✓ (2)	Occasional visitor
Killer whale	*Orcinus orca*	Nationally critical	DP, SO, Sp	Data deficient	Yes	✓ (2)	✓ (5)	**Likely**
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	✓ (72)	✓ (7)	**Likely**
Maui's dolphin	*Cephalorhynchus hectori maui*	Nationally critical	CD	Not assessed	Yes	✓ (18)	✓ (4)	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	✓ (1)	×	Rare visitor
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Migrant	SO	Data deficient	Yes	✓ (3)	✓ (****)	**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	✓ (18)	×	Possible
Pygmy sperm whale	*Kogia breviceps*	Not threatened	DP, SO	Data deficient	Yes	✓ (16)	×	**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	✓ (1)	✓ (7)	Occasional visitor
Shepherd's beaked whale	*Tasmacetus shepherdi*	Data deficient	SO	Data deficient	Yes	✓ (6)	×	Possible
Short-finned pilot whale	*Globicephala macrorhynchus*	Migrant	SO	Data deficient	Yes	✓ (1)	✓ (1)	Occasional visitor
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	SO	Least concern	Yes	✓ (2)	×	Possible
Southern elephant seal	*Mirounga leonina*	Nationally critical	RR, SO	Least concern	No	×	✓ (1)	Rare visitor ***
Southern right whale	*Eubalaena australis*	Nationally vulnerable	RR, SO	Least concern	Yes	✓ (1)	✓ (3)	Possible ***
Southern right whale dolphin	*Lissodelphis peronii*	Not threatened	DP,SO	Data deficient	Yes	✓ (8)	×	Occasional visitor ***
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	SO	Data deficient	No	×	×	Unlikely
Spectacled porpoise	*Phocoena dioptrica*	Data deficient	SO	Data deficient	No	✓ (1)	×	Possible
Sperm whale	*Physeter macrocephalus*	Not threatened	DP, TO	Vulnerable	Yes	✓ (28)	✓ (1)	**Likely**
Strap-toothed whale	*Mesoplodon layardii*	Data deficient	SO	Data deficient	Yes	✓ (13)	×	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 Waikato, Taranaki, Whanganui/Manawatu, Outer Marlborough Sounds, Golden Bay, Tasman Bay.*

**** 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 130 sighting records for Balaenoptera musculus spp. 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 (suborder Mysticeti)

The annual migrations of most species of baleen whale in the southern hemisphere are somewhat predictable whereby whales 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). There are however exceptions, for example Bryde's whales and pygmy blue whales which do not exhibit clear migratory patterns and instead are resident or semi-resident to particular habitats. More detailed knowledge of the migratory pathways for each species is provided in the individual species accounts below.

The Western Platform Multi-Client 3D Seismic Survey will take place over the summer months of 2017/18. At this time of the year most baleen whales will be aggregating at the Antarctic feeding grounds. It is possible that some southward migration may overlap with survey activities at the start of summer; although it is anticipated that the survey will be complete well before the northward migration gets underway in late autumn/winter. On this basis there is only limited potential for overlap between the migratory behaviours of baleen whales and survey operations.

5.2.1.1.1 Blue whale

Two subspecies of blue whale are known from New Zealand waters; the pygmy blue whale and the Antarctic blue whale. These two subspecies are difficult to distinguish without the use of genetic techniques, hence stranding and sighting data has not consistently differentiated between them.

In the last five years, research expeditions in the South Taranaki Bight have identified a population of resident or semi-resident pygmy blue whales that (as evident from acoustic data) are present here throughout most of the year (Torres et al., 2017). Data collected since 2012 has identified the South Taranaki Bight as a foraging ground for this subspecies, with data suggesting the krill *Nyctiphanes australis* is targeted here. Genetic analysis has confirmed that the individuals that use this area possess a distinct haplotype; hence these individuals are thought to comprise a unique population. The absolute distribution of blue whales in the South Taranaki Bight has been found to vary with oceanographic patterns that drive the distribution of their prey. In El Nino conditions whales tend to be located west of the Bight, but inside the Bight during more typical weather patterns (Torres & Klinck 2016). In February 2016 a field survey gathered the first evidence of breeding behaviour in the waters of, and to the west of, the South Taranaki Bight with 1) a high density of mother/calf pairs being observed and 2) the first ever aerial footage of blue whale nursing behaviour being documented (Torres & Klinck 2016).

The IUCN Red List of Threatened Species currently lists the Antarctic blue whale as "Critically Endangered" and the pygmy blue whale as "Data Deficient". In contrast, the New Zealand Threat Classification System classifies blue whales as "Migrant" and therefore does not designate a threat status. Blue whales are however listed as a "Species of Concern" under the DOC Code of Conduct. In light of the new evidence for blue whale breeding behaviour in the South Taranaki Bight, it is possible that the New Zealand Threat Classification status for blue whales will change in the future.

Blue whales have been detected both visually and 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).

The primary food source of blue whales is krill (euphausiids) which is captured both at the surface (lunge feeding) or at depth (down to 100 m) where feeding bouts typically last 10-20 minutes; although they are capable of diving to depths of up to 500 m for as long as 50 minutes (Todd, 2014). On account of blue whales having the highest prey demand of any predator (Rice, 1978; DOC, 2007), large aggregations of food are extremely important to this species. 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).

There have been 130 blue whale sighting records from within the Operational Area; and eight stranding events from coastal areas in the vicinity of the Operational Area. Strandings have occurred in the following locations: South Waikato, Taranaki, Whanganui/Manawatu, the outer Marlborough Sounds and Tasman Bay. Based on this assessment it is likely that blue whales (particularly pygmy blue whales) will be present in the Operational Area.

5.2.1.1.2 Minke whale

Antarctic minke whales and dwarf minke whales both occur in New Zealand waters. The distribution of the Antarctic minke is restricted to the southern hemisphere where it is very abundant in Antarctic waters in summer. They are seen at lower latitudes in other seasons, although outside of the summer months their distribution is less well-known (Reilly et al., 2008). The dwarf minke occurs over most latitudes in both hemispheres. In the southern hemisphere, they too feed in Antarctic waters in summer, with a broader latitudinal distribution in other seasons (Reilly et al., 2008). Outside of summer, dwarf minkes are thought to occur in shallower coastal water over the continental shelf (Jefferson et al., 2008; Perrin, 2009) than Antarctic minkes.

The DOC sighting and stranding data indicate that the distribution of minke whales extends around mainland New Zealand and throughout New Zealand’s subantarctic waters. There were 60 reported sightings of minke whales (both species) in New Zealand’s EEZ between 1970 and 2013, the majority of which were in spring (38%). This timing aligns well with the southern migration towards the Antarctic feeding grounds that these species utilise over the summer months. During this same period there were 85 reported strandings of dwarf minke whale and 17 reported strandings of Antarctic minke whales (Berkenbusch et al., 2013).

Minke whales feed on krill, crustaceans and small fish that they dive for in foraging bouts that last up to 20 minutes. Minke whales produce complex calls that have a frequency range of 50 Hz – 9.4 kHz (DOSITS, 2017).

No minke whale sightings have been made within the Operational Area; however 14 stranding events have been reported (two for Antarctic minkes and 12 for dwarf minkes). Strandings have predominantly occurred in Golden Bay, although South Waikato, Taranaki and Tasman Bay are also represented in the stranding record. Based on this assessment it is likely that minke whales will be present in the Operational Area.

5.2.1.1.3 Humpback whale

Humpback whales undertake the longest migration of any mammal (Jackson et al., 2014). They feed in Antarctic waters during summer months and travel north to tropical waters for breeding in the winter. Individuals from the “Southwest Pacific Ocean” population are known to migrate through New Zealand waters (Berkenbusch et al., 2013). These whales move northwards up the east coast of the South Island and through Cook Strait from May to August (Gibbs & Childerhouse, 2000). Recent tagging studies indicate that the majority of southward movements occur 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. The number of individuals recorded during these surveys ranged from 15 (in 2006) to 137 (in 2015) (DOC, 2015). Biopsy samples taken from the individuals seen in Cook Strait have been genetically matched to whales from Australia and New Caledonia.

Both male and female humpbacks produce communication calls, but only males emit the long, loud, and complex 'songs' associated with breeding activities. 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).

This species is considered an occasional visitor to the Operational Area, with most sightings expected in winter months.

Humpback whales are occasionally seen in coastal Taranaki waters, particularly between the months of May and August on their northern migration. There have been two humpback whale sightings from within the Operational Area; and five stranding events from coastal areas in the vicinity (four in Taranaki and one in Tasman Bay). Based on this assessment humpback whales are considered occasional visitors to the Operational Area (particularly during the winter months).

5.2.1.1.4 Bryde's whale

The distribution of Bryde's whales is typically restricted to tropical and warm temperate waters with a latitudinal range of between 40°N and 40°S (as summarised in Riekkola, 2013). A point of difference between this species and other baleen whales is that they do not migrate (Kato, 2002).

Around New Zealand, Bryde's whales are mainly found in the waters of the North Island, where the Hauraki Gulf in particular is thought to support a sub-population of whales that have some level of interaction with a wider regional population (Baker et al., 2010). Bryde's whales spend up to 90% of their time in the top 12 m of the water column (Constantine et al., 2012). As a result, ship strike was a major cause of mortality for this species near the Port of Auckland (Constantine et al., 2012); however, voluntary measures to reduce the likelihood of fatal ship strike have been in place near the here since 2013 and appear to be working well (i.e. only one ship strike incident was reported shortly after the measures were introduced, and none since) (D. Lundquist, pers comm.).

The only systematic surveys for this species around New Zealand have been restricted to the Hauraki Gulf and the east coast of Northland, where the Hauraki Gulf is regarded as an important breeding area (Baker & Madon 2007; Wiseman et al., 2011). Opportunistic sighting data is available for other regions and confirms that Bryde's whales are occasionally sighted in offshore Taranaki waters (Torres, 2012).

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

There have been two Bryde's whale sightings from within the Operational Area; and two stranding events from coastal areas in the vicinity of the Operational Area. The two stranding events occurred at Foxton Beach and Mokau. The Operational Area is typically considered to be outside the regional population strong-hold for this species. Based on this assessment it is possible that Bryde's whales could be present in the Operational Area.

5.2.1.1.5 Fin whale

Fin whales are found in offshore waters throughout the world (Reilly et al., 2013). Like other baleen whales, they head to high latitudes (between 50–65°S) to feed over the summer months (Miyashita et al., 1995) and move to warmer waters at lower latitudes during winter to breed.

The diet of fin whales is variable. Krill dominates their diet in the southern hemisphere whereas elsewhere, they consume range of species (fish, squid, krill and other crustaceans) (Miyashita et al., 1995; Shirihai & Jarrett, 2006). Torres (2012) suggested that fin whales, like blue whales, could also feed on krill aggregations in the South Taranaki Bight.

Fin whale communication vocalisations 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).

Three fin whale sightings have been made from the Operational Area and four strandings have been reported nearby: two in Taranaki, one in Golden Bay, and one in Tasman Bay. Based on this assessment, fin whales are believed to occasionally visit the Operational Area.

5.2.1.1.6 Sei whale

Sei whales in the South Pacific migrate to feed in subantarctic waters (45-60°S) during late summer, but spend the remainder of the year in subtropical waters (Miyashita et al., 1995). They tend to prefer warmer water temperatures than other baleen whales (typically in water temperatures between 8 and 18°C (Horwood, 2002)) and are seldom seen near sea ice (Mizroch et al., 1984).

Being a surface feeder, this species is one of the more conspicuous baleen whales at sea; foraging on mostly krill, copepods and small fish (Baker, 1999). Sei whale vocalisations are characterised by low frequency ‘downsweep’ calls. On average these calls transition from 82 to 34 Hz over 1.4 seconds (Baumgartner et al., 2008).

Seven sei whale sightings have been made from the Operational Area, and one stranding event for this species was reported from Golden Bay. Based on this assessment we conclude that sei whales may occasionally visit the Operational Area.

5.2.1.1.7 Southern right whale

The distribution of southern right whales is influenced by season, with most individuals spending summer months in latitudes 40 – 50°S (Oshumi & Kasamatsu, 1986) where they feed on dense aggregations of copepods and euphausiids (Tormosov et al., 1998; Rowantree et al., 2008) using a technique known as ‘skim feeding’ either at the surface or at depth (Braham & Rice, 1984). Southern right whales are slow moving whales, often swimming at speeds less than 9 km/hr making them vulnerable to ship-strikes. These whales produce a range of different vocalisations. In New Zealand waters, a majority of ‘upcalls’ are recorded and on average vocalisations have frequencies of below 1 kHz (Webster & Dawson, 2011).

Southern right whale populations around New Zealand are making a recovery following the cessation of historic whaling. Pre-exploitation abundance of southern right whales here was estimated to have been between 28,800 and 47,100 individuals (Jackson et al., 2016); however, at the end of the whaling era only 30–40 mature females were thought to remain (Jackson et al., 2016). Whale numbers around New Zealand are currently thought to represent approximately 12% of pre-exploitation abundance (Jackson et al., 2016).

Southern right whales are the only baleen whale known to breed in New Zealand waters; the coastal waters around mainland New Zealand represent a historic calving ground for this species, with recent evidence suggesting that a slow recolonization of this 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).

Those individuals around mainland New Zealand and the subantarctic are part of a single genetic population (Carroll et al., 2011). This population ranges between two winter breeding grounds; the Auckland Islands and mainland New Zealand; where Port Ross in the Auckland Islands is the principal calving area (Rayment et al., 2012).

Three sightings of this species have been made from the Operational Area and only one stranding has been reported nearby (from Taranaki in 1890). 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. Its summer distribution is typically further offshore. Based on this assessment, it is possible that southern right whales could be present in the Operational Area.

5.2.1.1.8 Pygmy right whale

Pygmy right whales are the smallest of the baleen whales, growing to only 6.4 m long (Baker, 1999). The diet of this species consists largely of calanoid copepods (Reilly et al., 2008a) and euphausiids (Kemper, 2002). With regard to the acoustic repertoire of this species, recordings of a juvenile pygmy right whale from Australia documented at least one type of call: a short thump-like pulse with a down-sweep in frequency and decaying amplitude (Dawbin & Cato, 1992).

Few live sightings have been made for this species; hence distributional information is relatively scant (Reilly et al., 2008a). The Australasian distribution for this species was described by Kemper (2002) as being 32 – 47 °S, with young calves recorded in waters from 35 – 47 °S. In New Zealand, sightings typically occur near Stewart Island and Cook Strait (Kemper, 2002). In 2001 a group of 14 pygmy right whales was seen at 46°S southeast of New Zealand (Matsuoka et al*.,* 2005). Kemper (2013) suggests an association between pygmy right whales and areas of high marine productivity.

Although no sightings of pygmy right whales have been recorded in the Operational Area, eighteen strandings have been reported from near the Operational Area. These stranding records (which have occurred predominantly in Golden Bay, but also Taranaki and the outer Marlborough Sounds) suggest that pygmy right whales could possibly be present in the Operational Area.

Toothed whales (suborder Odontoceti)

5.2.1.1.9 Sperm whale

Sperm whales have a wide geographical and latitudinal distribution, and are usually found in open ocean waters deeper than 1,000 m. 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. Systematic surveys of sperm whale distribution in New Zealand waters are limited to the Kaikoura region which is home to a small number of resident male sperm whales that feed in the submarine canyons (Arnold, 2004). Groups of females have occasionally been seen off Kaikoura (two observations in ten years of study; Richter et al., 2003); however, male sperm whales are present year round within a few kilometres of the shore (Jaquet et al., 2000). In Taranaki, Torres (2012) reported that sperm whale sightings typically occurred in deep offshore water and were limited to the summer months. Although all whales have significant cultural importance in New Zealand, sperm whales in particular are commonly recognised as taonga (treasure) to Māori.

This species is reliant on echolocation to locate prey and for navigation. The echolocation clicks that sperm whales use during foraging enable them to determine the direction and distance of prey (Ocean Research Group, 2015). 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).

One sperm whale sighting has been reported from the Operational Area, and 28 sperm whale strandings have occurred nearby. The majority of strandings have occurred in Taranaki and Golden Bay, with lower stranding numbers reported for South Waikato, Whanganui/Manawatu and Tasman Bay. Based on this assessment, sperm whales are likely to be present in the Operational Area.

5.2.1.1.10 Pygmy sperm whale

Pygmy sperm whales are seldom seen at sea on account of their low profile in the water and lack of a visible blow; for this reason little information is available on this species.

Prey species of pygmy sperm whales include cephalopods, fish and occasionally crustaceans (Shirihai & Jarrett, 2006). Little is known of the acoustics of this species; however, data collected from live stranded animals has indicated that the species emits click trains between 60 kHz and 200 kHz (Marten, 2000).

Despite no live sightings being recorded for the Operational Area, 16 strandings have been reported near the Operational Area (from South Waikato, Taranaki and Whanganui/Manawatu). Based on this assessment, pygmy sperm whales are likely to occur in the Operational Area.

5.2.1.1.11 Pilot whale

There are two species of pilot whale; the long-finned pilot whale and the short-finned pilot whale, both species are present in New Zealand waters; although the short-finned pilot whale is less frequently encountered here as it prefers warmer subtropical habitat. Sightings of pilot whales in Taranaki waters are reasonably common with most occurring in summer (Torres, 2012).

Pilot whale strandings are common around the New Zealand coastline; generally peaking in spring and summer (O'Callaghan et al., 2001), with Farewell Spit (which lies directly south of the Operational Area) being a recognised hotspot for pilot whale mass stranding incidents. Stranding data for Farewell Spit 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. Long-finned pilot whales accounted for virtually all of these stranding events with only one short-finned pilot whale mass stranding recorded in 1977. November, December and January were the most common months in which mass strandings occurred.

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 studies indicate that pilot whales predominantly feed on cephalopods; usually arrow squid and common octopus (Beatson et al., 2007).

Eight sightings of pilot whales have been reported in the Operational Area, including one sighting of approximately 100 animals near Maui-A Platform. Seventy seven strandings have occurred in the vicinity (one involved short-finned pilot whales, 72 involving long-finned pilot whales and the remaining four couldn't be identified to species level). As expected, the majority of strandings occurred in Golden Bay; however Taranaki, Whanganui/Manawatu and Tasman Bay also reported strandings. Based on this assessment it is likely that long-finned pilot whales will be encountered in the Operational Area.

5.2.1.1.12 Killer whale

Four morphological forms of this species are recognised globally (Types A – D) (Baker et al., 2010); with the majority of killer whale sightings in New Zealand coastal waters believed to be Type A (Visser, 2007). Type A killer whales have been recorded around all regions of coastal New Zealand (Visser, 2000), including the Operational Area. There is some evidence to suggest a temporal pattern of sightings in the South Taranaki Bight region, with killer whales more likely to be present from November to February (Visser, 2000). However, Torres (2012) found sightings to be relatively evenly distributed through time and postulated that the peak in summer months may simply reflect an observational bias. In 1997, the population size of Type A killer whales in New Zealand was estimated by photo identification techniques at 115 individuals (95% CI 65–167) (Visser, 2000). Small groups of killer whales are typical around New Zealand where they travel 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.

Killer whales echolocate and produce tonal sounds (whistles). Echolocation characteristics vary between groups of 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).

Five killer whale sightings have been reported from the Operational Area, including one sighting of 25 individuals from the Maui-B Platform. At least one killer whale calf was noted in this group. Two strandings have been reported from around the Operational Area, one from Tasman Bay and one from Taranaki. Based on this assessment, killer whales are likely to be present in the Operational Area.

5.2.1.1.13 False killer whale

This species is widespread in tropical and warm temperate waters (Baird, 2002), and although there is a scarcity of data on this species in New Zealand, false killer whales have been reported to make close associations with bottlenose dolphins in shallow waters off north-eastern New Zealand (Zaeschmaer et al., 2013). This presence in shallow waters seems to coincide with the seasonal influx of warm oceanic waters between December and May (Zaeschmaer et al., 2013). False killer whales prey primarily on fish and cephalopods in dives of up to 500 m (Shirihai & Jarrett, 2006).

One sighting of a false killer whale has been reported in the Operational Area (of seven individuals), and three strandings have been reported: one each in South Waikato, 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.

5.2.1.1.14 Beaked whales

Although, thirteen species of beaked whales have been reported in New Zealand (Baker et al., 2016), their elusive behaviour at sea means that very little is known about their distributions here (Baker, 1999). Only one live sighting of a beaked whale has been made within the Operational Area; this was of a group of two Cuvier’s beaked whale that were observed travelling close to the Maui-B Platform. The majority of knowledge about beaked whales comes from stranded individuals and **Table 10** outlines what species have stranded near the Operational Area and provides a brief account of the ecology of each of these species. 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). They are deep divers and feed predominately on deep-water squid and fish 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;
- One species (Gingko-toothed whale) may be a rare visitor to the Operational Area; and
- Five species (Blainville's/Dense beaked 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 Taranaki x 1 Marlborough Sounds x 1 **TOTAL = 6**	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)*	Golden Bay x 1 Whanganui/Manawatu x 1 Taranaki x 2 **TOTAL = 4**	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).
Gingko-toothed whale *(Mesoplodon ginkgodens)*	Golden Bay x 1 Tasman Bay x 1 Taranaki x 1 **TOTAL = 3**	Most stranding and capture records for this species are from the tropical and warm temperate waters of the Indo-Pacific (esp. Japan). Only a few records from New Zealand. Biology unknown (Taylor et al., 2008b).
Gray's beaked whale *(Mesoplodon grayi)*	Golden Bay x 4 Tasman Bay x 11 Marlborough Sounds x 1 Whanganui/Manawatu x 8 Taranaki x 10 South Waikato x 2 **TOTAL = 36**	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)*	Golden Bay x 5 Tasman Bay x 1 Whanganui/Manawatu x 3 Taranaki x 4 **TOTAL = 13**	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)*	Golden Bay x 1 Whanganui/Manawatu x 1 **TOTAL = 2**	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)*	Tasman Bay x 1 Whanganui/Manawatu x 1 Taranaki x 4 **TOTAL = 6**	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)*	Golden Bay x 1 Tasman Bay x 4 Whanganui/Manawatu x 8 Taranaki x 5 South Waikato x 2 **TOTAL = 20**	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).

5.2.1.1.15 Bottlenose dolphin

Bottlenose dolphins occur globally in cold temperate and tropical seas, with New Zealand being the southernmost extent of their range. Three genetically distinct 'in-shore' populations of bottlenose dolphins are recognised in New Zealand, these are described by Baker et al. (2010) as 450 individuals off the northeast coast of Northland, 60 individuals in Fiordland, and an unquantified population in coastal waters between the Marlborough Sounds and the West Coast. In addition to these inshore populations, an 'offshore' population of at least 163 individuals is thought to occur in offshore waters right around New Zealand (Zaeschmar et al., 2013). The offshore dolphins typically form larger groups than those formed by inshore dolphins (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.

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

One sighting of fifteen bottlenose dolphins is reported in the DOC Sightings Database for the Operational Area and 16 strandings have been recorded in the vicinity. The majority of these strandings occurred in Tasman Bay; however strandings have also occurred in Golden Bay, the outer Marlborough Sounds, Whanganui/Manawatu and Taranaki. Based on this assessment, bottlenose dolphins are likely to occur in the Operational Area.

5.2.1.1.16 Common dolphin

The common dolphin (also known as the short-beaked common dolphin) occurs in waters encompassing all regions of New Zealand (Berkenbusch et al., 2013). Total abundance of the New Zealand population is unknown; however, based on the frequency of sightings it is likely that numbers are substantial. Common dolphins are the most frequently encountered cetacean species in the South Taranaki Bight (Torres, 2012). Most sightings occur over summer months, but this seasonality could be a reflection of observational bias (Torres, 2012).

Common dolphins are highly social and often form large groups that include thousands of individuals. They occur in water depths ranging from 6 – 141 m (Constantine & Baker, 1997). Stomach content analysis of common dolphins in New Zealand indicates that jack mackerel, anchovy and arrow squid are their primary prey species (Meynier et al., 2008).

Common dolphins use a variety of vocalisations including whistles, echolocation click trains and burst pulse calls. Echolocation click trains are involved in locating prey and navigation whereas burst pulse calls and whistles are a form of communication. Petrella et al. (2012) determined the whistle characteristics of common dolphins in the Hauraki Gulf, indicating that the average frequency and length of whistles are 10 – 14 kHz and 0.27 seconds, respectively.

Forty one sightings records of common dolphins have been made in the Operational Area, with the single largest sighting being of approximately 420 individuals including calves. Strandings of this species are also relatively common from the vicinity of the Operational Area, with a total of 77 reported as follows; 20 in Golden Bay, 15 in Tasman Bay, three in the outer Marlborough Sounds, eight in Whanganui/Manawatu, 18 in Taranaki, and 13 in South Waikato. Based on this assessment, common dolphins are likely to be present in the Operational Area.

5.2.1.1.17 Dusky dolphin

Dusky dolphins are present year round in New Zealand waters (Berkenbusch et al., 2013) and typically occur in water depths less than 2,000 m above the continental shelf and slope. Little is known about dusky dolphin movements, but photo-identification data confirms that individuals travel up to 1,000 km between locations around the South Island (Wursig et al., 2007). This species is more commonly seen in cooler waters around the South Island and lower North Island (Wursig et al., 2007) and 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). This species tends to spend more time in offshore waters during the winter months (Wursig et al., 2007).

Dusky dolphins feed on a range of pelagic and benthic prey including southern anchovy, squid, hake and lantern fishes (Hammond et al., 2008). They generally forage in relatively shallow waters, but can forage up to 130 m deep. 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).

Two sightings of dusky dolphins have occurred in the Operational Area and 32 two strandings have occurred in the vicinity. The majority of these stranding reports (21) occurred in Tasman Bay; however strandings of this species were also reported from Golden Bay, Whanganui/Manawatu and Taranaki. On the basis of this assessment, dusky dolphins are likely to be present in the Operational Area.

5.2.1.1.18 Hector’s & Maui’s dolphins

There are two subspecies of Hector’s dolphin; the South Island Hector’s dolphin and the Maui’s dolphin. In general, Maui’s dolphins are present on the west coast of the North Island, with South Island Hector’s dolphins being present around the South Island. Over the last 40 years, numbers of both subspecies have declined significantly, largely on account of bycatch in coastal fisheries (Currey et al., 2012). 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 two subspecies cannot be readily differentiated at sea; which complicates sightings records. However, there is no evidence to suggest that the ecology of the two subspecies is substantially different (Torres, 2012). Both subspecies have coastal distributions thought to be largely constrained within the 100 m isobath (Slooten et al., 2006; Du Fresne, 2010). Maui’s dolphins have been observed out to 12 Nm offshore during research surveys (DOC, 2017n) and South Island Hector’s dolphins out to 20 Nm offshore (MacKenzie & Clement, 2014); with unverified sightings of both subspecies out to 24 Nm (Du Fresne, 2010). Offshore sightings for both subspecies are more common in winter months.

Three populations of Hector’s dolphins are of relevance to the Operational Area, these are the West Coast South Island (WCSI) population; the East Coast South Island (ECSI) population and the Maui’s dolphin. The WCSI population extends from Milford Sound to Farewell Spit and numbers 5,490 individuals (MacKenzie & Clement, 2016). The ECSI population extends from Farewell Spit to Nugget Point and is estimated to be comprised of 8,968 individuals (Mackenzie & Clement, 2016). In the top of the South Island, the main concentration of dolphins is found in Clifford and Cloudy Bay, at the eastern entrance to Cook Strait. Hector’s dolphins are also occasionally observed in Tasman and Golden Bays; however, it is unknown if these individuals are from the WCSI or ECSI populations.

Maui’s dolphins are found only along the West Coast of the North Island, with a population strong-hold between Manukau Harbour and Port Waikato (Slooten et al., 2005). The total population distribution is slightly wider; extending from Maunganui Bluff to Whanganui (Currey et al., 2012). 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 dolphin in a commercial set net off Cape Egmont in January 2012 confirms their presence in coastal Taranaki waters (DOC 2017).

South Island Hector's dolphins have been genetically identified off the west coast of the North Island (Hamner et al., 2012), confirming some movement between areas. 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). It is possible therefore that those dolphins in transit could pass through the Operational Area.

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.

Three sightings of Hector's/Maui's dolphins have been reported in the Operational Area: two sightings were of solitary animals seen during oil and gas operations (drilling and production), and one sighting of ten individuals was made from the Maui-B production platform. Hence, despite their low densities off the Taranaki coast, it is possible that both subspecies could occasionally be present in the Operational Area. Thirty two stranding events have been reported near the Operational Area (nine from Golden Bay, three from Tasman Bay, one from the outer Marlborough Sounds, two from Whanganui/Manawatu, 13 from Taranaki and four from South Waikato). On the basis of this assessment it is possible the Hector's/Maui's dolphins could be present in the Operational Area.

The offshore nature of the survey serves to reduce the likelihood of encountering this threatened species during the Western Platform Multi-Client 3D Seismic Survey. However, an increase in potential overlap with dolphin habitat occurs where the Operational Area approaches the coast, in particular the West Coast North Island Marine Mammal Sanctuary. It is also possible that the Operational Area overlaps with the transit route occasionally used by South Island Hector's dolphins as they travel to the North Island; however, these long-range movements are thought to occur only very occasionally (see Hamner et al., 2013).

Because of the threat status and the low density of Hector's and Maui's dolphins in Taranaki waters, special protocols will be implemented during the Western Platform Multi-Client 3D Seismic Survey to facilitate immediate reporting of either subspecies to DOC Taranaki in the event that they are encountered (see **Appendix D**).

5.2.1.1.19 Southern right whale dolphin

Sightings of this species typically occur in cool, deep, offshore temperate and subantarctic waters between 30 and 65°S (Hammond et al., 2012). The range within this latitudinal band is thought to be circumpolar (Hammond et al., 2012). Despite no abundance estimates being available, this species is considered to be relatively common throughout its range (Jefferson et al., 1994). No information is available on the acoustic repertoire of this species; however, it presumably uses echolocation to navigate and locate food as with other odontocetes.

Around New Zealand, the southern right whale dolphin is seldom observed at sea; however, from the occasional sightings that have been made it is apparent that these dolphins sometimes travel in large groups of up to 1,000 individuals (Baker, 1999).

No live sightings of this species have been reported in the Operational Area, but eight strandings have been reported in the vicinity. Most of these stranding incidents occurred in Golden Bay (six), with one each also occurring in Tasman Bay and the outer Marlborough Sounds. Based on this assessment, this species is expected to occasionally visit the Operational Area.

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 – Rare visitor;
- 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;
- Crabeater 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. All other species are routinely only found along the southern coast of the South Island, or in the subantarctic.

5.2.2.1 New Zealand fur seal

New Zealand fur seals are native to New Zealand and Australia and have a wide distribution around mainland New Zealand and its offshore islands. Historically, the culmination of subsistence hunting and commercial sealing drastically reduced the population size of this species (estimated pre-human population of 3,000,000) to an estimated 100-200 breeding individuals at the peak of commercial harvest (Emami-Khoyi et al., 2017). Since protection in 1894, this species has proceeded to recolonise its historic range, with an increase in population size and an expansion northwards of its breeding distribution (Lalas & Bradshaw, 2001); however breeding colonies on mainland New Zealand are mostly located in the South Island. A reliable contemporary total abundance estimate is not available for this species, but estimates in the vicinity of 100,000 individuals have been suggested (Harcourt, 2001).

New Zealand fur seals feed on fish (e.g. lantern fish, hoki, barracouta, ahuru and jack mackerel) and cephalopods (arrow squid and octopus) (as summarised by Baird, 2011). Foraging dives last for up to 12 minutes and reach depths of ~ 200 m (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). The continental shelf break is a common foraging location for this species.

The breeding season for New Zealand fur seals occurs from mid-November to mid-January, with peak pupping 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).

In the vicinity of the Operational Area there are six breeding colonies as listed below:

- Sugar Loaf Islands, off New Plymouth;
- Stephens Island, outer Marlborough Sounds;
- Tonga Island, Tasman Bay;
- Separation Point, Golden Bay;
- Pillar Point, just south of Farewell Spit; and
- Archway Islands, just south of Farewell Spit.

This species will definitely be encountered in the Operational Area where concentrations at sea may occur around oil and gas facilities which provide seals with offshore haul-out opportunities.

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, 2017a) and 84 species breed in New Zealand waters (MacDiarmid et al., 2015). Approximately half of the breeding seabirds are classified as endemic (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. 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 is presented in **Table 11**.

Taranaki Regional Council's Draft Coastal Plan has identified a number of seabirds 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. Caspian terns, grey-faced petrels, and black-fronted terns are also considered regionally distinctive by Taranaki Regional Council (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
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
Black petrel*	*Procellaria parkinsoni*	Nationally Vulnerable
Flesh-footed shearwater*	*Puffinus carneipes*	Nationally Vulnerable
Caspian tern*	*Hydroprogne caspia*	Nationally Vulnerable
Red billed gull*	*Larus novaehollandiae scopulinus*	Declining
Hutton's shearwater	*Puffinus huttoni*	Declining
NZ white-capped mollymawk	*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

Common Name	Scientific Name	NZ Threat Status (Robertson et al. 2017)
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	*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
Black browed mollymawk	*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. No seabird breeding occurs in the Operational Area; however there are 15 species of seabird that seasonally occupy coastal breeding locations in areas adjacent to the Operational Area. These species are listed in **Table 12** and the locations of their breeding colonies are shown in **Figure 11**. Of particular importance are the Nga Motu/Sugar Loaf Islands and coastal estuaries in the South Taranaki and Whanganui regions such as the Waikirikiri Lagoon, and Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei River estuaries (Thomson, 2015).

Table 12 Breeding Seabirds in the Vicinity of the Operational Area

Species	Breeding season	Breeding location/s
Caspian tern	September – January	Farewell spit and Tasman Bay
White-fronted tern	October – January	Coastal New Zealand
Australasian gannet	August – March	Farewell Spit
Fairy prion	October – February	Stephens Island
Flesh-footed shearwater	September - May	Nga Motu
Fluttering shearwater	August – January	Stephens Island
Grey-faced petrel	March – January	Nga Motu
White-faced storm petrel	August - April	Nga Motu
Diving petrel	August – December	Stephens Island, Nga Motu, Kapiti Island
Northern little blue penguin	July - February	Stephens Island, Nga Motu, Marlborough Sounds
Red billed gull	September - January	Farewell Spit, Stephens Island
Sooty shearwater	November – May	Stephens Island, Kapiti Island
Southern black-backed gull	September – March	Farewell Spit, Stephens Island, Patea
Spotted shag	varies through range	Stephens Island
Pied shag	varies through range	Farewell Spit, Stephens Island
Black shag	varies through range	Farewell Spit
Little shag	varies through range	Farewell Spit
Caspian tern	September – January	Farewell Spit
White-fronted tern	October - January	Farewell Spit, Stephens Island
Northern NZ dotterel	August - February	Cape Egmont
Variable oyster catcher	September – March	Farewell Spit
King shag	March - September	Marlborough Sounds

GPS tracking data has recently identified the South Taranaki Bight as a foraging ground for little blue penguins (*Eudyptula minor*) (Poupart et al., 2017). Little blue penguins were initially thought to forage within 30 km of their nesting sites; however Poupart et al. (2017) have shown that breeding birds from the Marlborough Sounds can forage up to 214 km from their nests. 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). After incubation, the chicks are fed by their 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 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'. Such 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).

The Motueka River and Spit, and Farewell Spit (in Tasman, south of the Operational Area) have been identified as Important Bird Areas on land based on the following criteria:

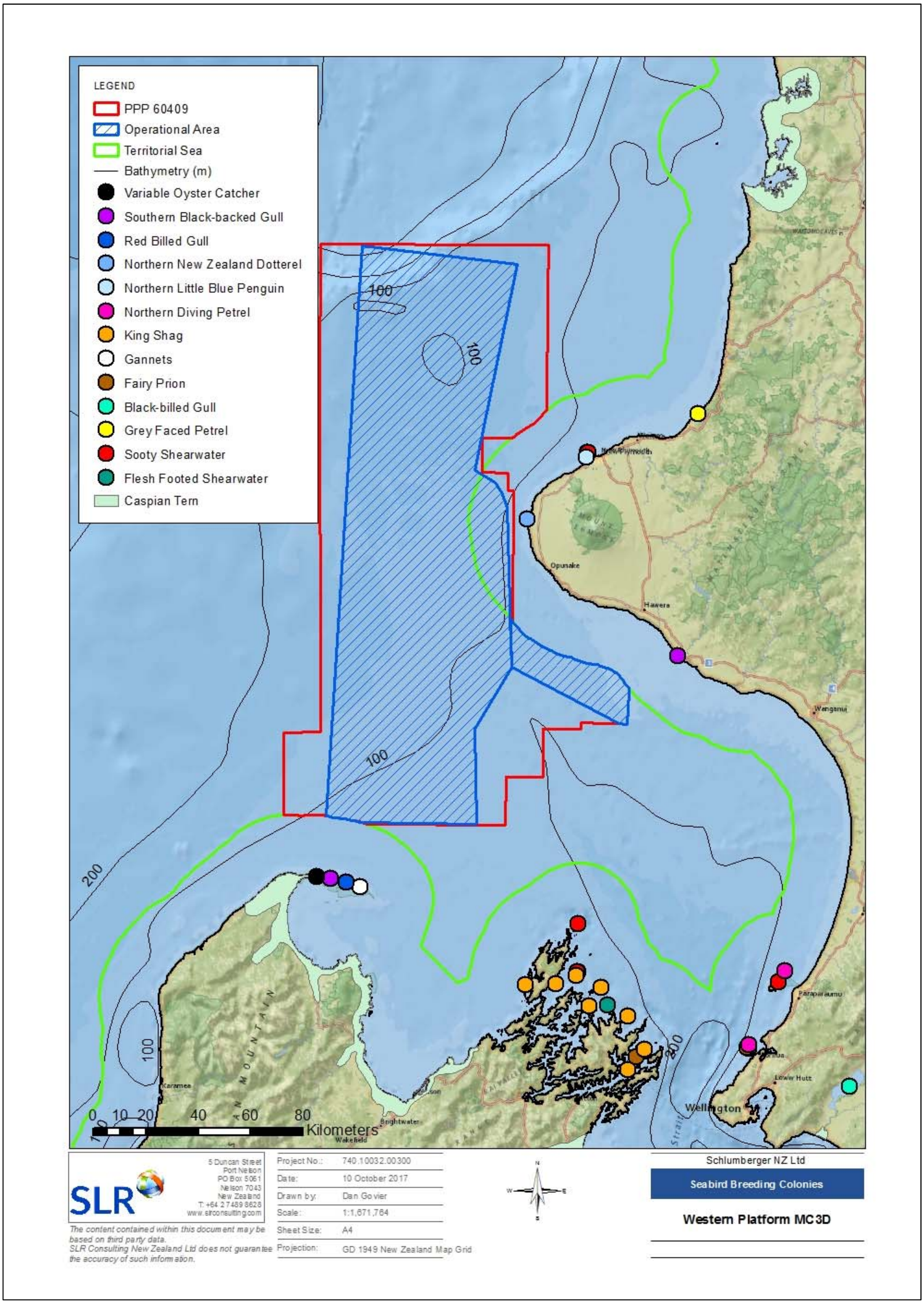
- Motueka River and Spit – A1: contains more than threshold numbers of one or more globally threatened species. Trigger species are breeding populations of black-billed gulls and black-fronted terns (Forest & Bird, 2016); and
- Farewell Spit – A1: contains more than threshold numbers of one of more globally threatened species; and contains more than threshold numbers of one of more congregatory species including, Aii (>1% global population of seabirds) and A4iii (>10,000pairs, seabirds or 20,000 individuals, waders). Trigger species are breeding population of Australasian gannet (A4ii), resident populations of Australasian bittern (A1), and the large presence of birds belonging to the 'shorebird' group (A4iii) (Forest & Bird, 2015).

It is important to note that the above mentioned Important Bird Areas on land do not overlap with the Operational Area.

There are two offshore Important Bird Areas of relevance to the Operational Area. These areas are used by seabird colonies for feeding, maintenance behaviours and social interactions, and also encompass the passage of pelagic species to and from colonies, and congregations close to breeding islands (Forest & Bird, 2014a). The seaward extensions and pelagic areas identified as Important Bird Areas are listed below along with the relevant listing criteria (Forest & Bird, 2014a):

- West Coast North Island – A4ii: contains more than one percent of the world population of one or more congregatory species (Australasian gannet and New Zealand fairy tern). It is worth noting that this Important Bird Area does not enter the Operational Area; and
- Cook Strait – 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'). This Important Bird Area covers the entire Cook Strait and South Taranaki Bight areas, therefore the Operational Area south of Cape Egmont will overlap with this Important Bird Area.

Figure 11 Seabird Breeding Colonies in the Vicinity of the Operational Area



5.2.4 Marine Reptiles

There are nine species of marine reptiles known to occur in New Zealand waters; the logger head turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), leatherback turtle (*Dermochelys coriacea*), yellow-bellied sea snake (*Pelamis platurus*), Saint Grion's sea krait (*Laticauda colubrina*), common sea krait (*Laticauda laticaudata*) and the banded sea krait (*Laticauda colubrina*) (DOC, 2017b; DOC, 2017c). Apart from the leatherback sea turtles, marine reptiles are generally found in warm temperate waters and 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 and fully protected under the Wildlife Act 1953 (Godoy, 2016; DOC, 2017b)

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 'strays' and occasional visitors to New Zealand waters, 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 and being present year round 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 could also actively utilise New Zealand waters.

Marine reptiles do occasionally visit the south-western coast of the North Island, although mainly during summer months when the warmer currents push down the western side of New Zealand. Leatherback turtles and yellow bellied sea snakes have been observed in Taranaki waters (DOC, 2017d); however, they are rare visitors and are not routinely present. On account of this, marine reptile presence 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.

Over the summer months when warmer currents move down from the north, a number of larger pelagic species visit Taranaki waters. The most common of these 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) 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 instead it lists the main ones.

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; O'Driscoll *et al*., 2003) [1] NABIS Database [2] McMillan *et al*. (2011) [3]		
Albacore tuna [2]	Greenback jack mackerel [3]	Rough skate [1,2,3]
Barracouta [1,2,3]	Gurnard [1,2,3]	Rubyfish [1,2,3]
Basking shark [2]	Hake [2,3]	Sand flounder [2]
Bass [2]	Hapuku [1,2,3]	Scaly gurnard [1,3]
Black marlin [2]	Hoki [1,2,3]	School shark [1,2,3]
Blue cod [1,2,3]	Horse mackerel [2]	Seal shark [2]
Black mackerel [1,2,3]	Jack mackerel [1]	Sepiolid squid [1]
Blue marlin [2]	John dory [1,2,3]	Short tail stingray [1]
Blue moki [2]	Kahawai [1,2,3]	Short-tailed black ray [3]
Blue shark [2,3]	Kingfish [2,3]	Silver conger [3]
Blue warehou [1,2]	Koheru [2]	Silver dory [1,2,3]
Bluenose [2]	Leatherjacket [1,2,3]	Silver warehou [1,2,3]
Brill [2]	Lemon sole [1,2]	Silverside [1,3]
Broadbill swordfish [2]	Ling [1,2,3]	Skipjack tuna [1,2]
Broadnose sevengill shark [3]	Longfinned beryx [2]	Slender jack mackerel [3]
Bronze whaler shark [2,3]	Mako shark [1,2,3]	Slender tuna [1]
Brown stargazer [3]	Moonfish [2]	Sloan's arrow squid [1,2]
Butterfly perch [1,3]	Murphy's mackerel [1,2]	Smooth skate [1,2,3]
Capro dory [1,3]	New Zealand sole [2]	Snapper [1,2,3]
Carpet shark [1,3]	Northern spiny dogfish [1,2,3]	Snipefish [3]
Common roughy [3]	Oblique banded rattail [3]	Southern conger [3]
Common warehou [3]	Opalfish [3]	Spiny dogfish [1,2,3]
Cucumberfish [1,3]	Pacific Bluefin tuna [2]	Spotted gurnard [3]
Dark ghost shark [1,2,3]	Pilchard [1,2,3]	Spotted stargazer [1,2,3]
Eagle ray [1,3]	Porae [2]	Striped marlin [2]
Electric ray [3]	Porbeagle shark [2,3]	Tarakihi [1,2,3]
Escolar [2]	Porcupine fish [1,3]	Thresher shark [1,2,3]
Frostfish [1,2,3]	Ray's bream [2,3]	Trevally [1,2,3]
Gemfish [1,2,3]	Red cod [1,2,3]	Turbot [2]
Giant stargazer [1,2,3]	Red perch/Jock Stewart [1,2,3]	Two saddle rattail [2,3]
Golden mackerel [2]	Red snapper [2]	Yellowtail jack mackerel [3]
Gould's arrow squid [1,2]	Redbait [1,2,3]	White warehou [2]
Great white shark [2]	Rig [1,2,3]	

There are eight species of fish listed as protected under Schedule 7A of the Wildlife Act 1953; basking shark, deepwater nurse shark, great white shark, manta ray, oceanic white-tip shark, spiny-tailed devil ray, spotted black grouper, and whale shark. Additionally, the great 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 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, with any disruption to spawning or pupping activity potentially resulting in a reduction in recruitment (Morrison et al., 2014). Spawning activity may range from large spawning aggregations, 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). Information on the spawning and pupping of New Zealand's fish is typically limited, with detailed information about spawning activity only well known for some species (e.g. commercially important species such as orange roughy and hoki). Data on the presence of spawning/pupping locations usually relies on reported catch of spent or ripe running females in research trawls. Species potentially spawning/pupping within the Operational Area and the approximate timing of such events have been provided in **Table 14** based on Morrison et al. (2014), Hurst et al. (2000) and O'Driscoll et al. (2003).

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

Rocky reefs in the South Taranaki Bight are typically found within the CMA, for example the North and South Traps which support leatherjackets (*Parika scaber*), blue cod (*Parapercis colias*), red moki (*Cheilodactylus spectabilis*) and blue maomao (*Scorpis violacea*) (McClary, 2014). Fish species common to the Patea Shoals area include opalfish, triplefins and flatfish (Beaumont et al., 2015).

Table 14 Fish Species Potentially Spawning in the Operational Area

Species common name	Spawning season
Barracouta	July – October then January – March
Blue mackerel	Summer
Blue warehou	October
Jack mackerel	July, September, and December – February
John dory	December – March
Red cod	July - September
Red gurnard	December – February
Rig	Spring/Summer
Rubyfish	November, January and February
School shark	Spring/Summer
Snapper	October – March (November – December peak)
Tarakihi	March – May

New Zealand has 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 is also found 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 the 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 the life cycle of these eels, however three distinct migrations have been observed in New Zealand:

- Elvers (two year old eels) move 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, an upstream migration occurs of the four to five year old eels. This migration further upstream occurs annually in January (Cairns, 1950).
- The third migration involves the movement of sexually mature adult eels (known as tuna heke or tuna whakaheke) 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 meet the mature males. First to enter the sea are short-finned males followed by short-finned females. Long-finned eels show a similar pattern with the males migrating before 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 (eel spawning has never been observed), deep ocean trenches (DOC, 2017e) near Fiji and New Caledonia are thought to be important spawning grounds (NIWA, 2017). Short-finned and long-finned eels are semelparous; they breed only once at the end of their life (DOC, 2017e), therefore there is no southern migration of adults returning to New Zealand.
- A fourth, unobserved migration occurs involving the leptocephalus (transparent leaf-shaped eel larvae). The leptocephalii reach New Zealand waters by drifting on ocean currents. Once reaching New Zealand coastal waters they change into eel-shaped 'glass eels' and move into river mouths and estuaries (Te Ara, 2017b) before commencing their freshwater life-cycle as elvers.

5.2.6 Cephalopods

All cephalopods consist of a mantle, head, and eight arms (and two long tentacles in the case of some squid). New Zealand cephalopods include the cuttlefish, squid, octopus and vampire squids.

There are 42 species of octopus known to occur in New Zealand waters. Octopuses mainly live on the seafloor and are the largest predators on reefs, feeding on crustaceans and shellfish (Te Ara, 2017c). Due to their affiliation with reef habitats, the Operational Area is not considered to be important for octopuses; however, benthic surveys for offshore monitoring surrounding the Taranaki oil fields have reported catches of small octopus, more specifically the species *Macroctopus maorum* (pers. obs. N. Pannell).

New Zealand has a diverse assemblage of squid and related groups; more than 85 species have been found in New Zealand, the majority of which are open-sea animals (Te Ara, 2017d). 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 the concentrations for these species occur from southern and subantarctic fishing grounds (Deepwater Group, 2017).

5.2.7 Benthic Invertebrates

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., 2015). 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).

An assessment of subtidal benthic habitats in the South Taranaki Bight was conducted by Anderson et al., 2013 and revealed both soft sediment habitats, hard rock habitats and mudstone habitats. The soft sediments and the mudstone habitats were characteristically low in species abundance and diversity, while in contrast, the hard rock habitats were reported to support abundant and diverse macrobenthic assemblages. A number of these hard rock habitats are recognised as ecologically significant including the North and South Traps, and Four Mile Reef (see **Section 5.3.1.2**).

The eastern extension of the Operational Area extends into a region known as Patea Shoals. Habitat analysis of this region was undertaken by Beaumont et al. (2015) who conducted visual observations from 144 sites, infauna samples from 103 sites and macrofauna samples from 116 sites across the inner shelf, mid-shelf and deeper offshore areas of Patea Shoals. The findings of this analysis are summarised by the bullet points below:

- The most common habitat type was rippled sand which occurred mostly on the inner shelf and mid-shelf. This habitat was characterised by low biodiversity and low densities of infauna and epifauna which is 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.

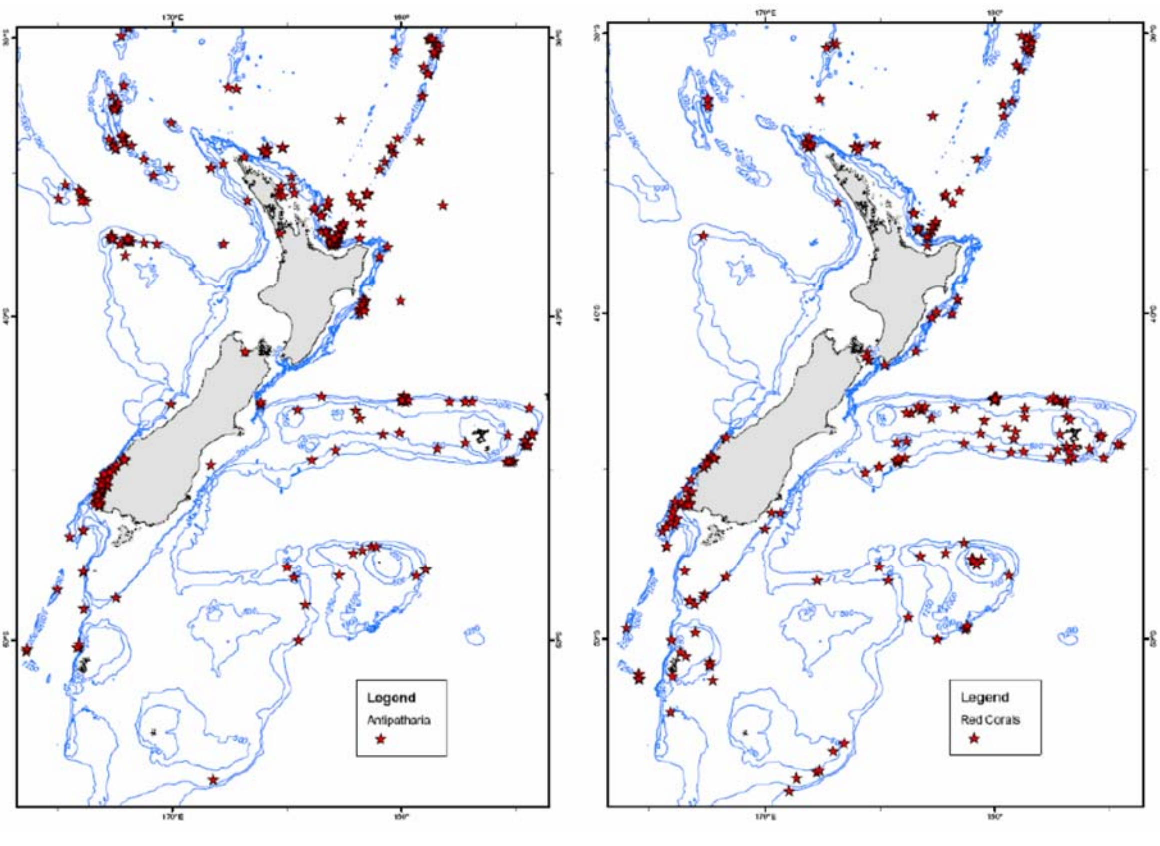
The soft benthic ecosystems further offshore of Patea Shoals have relatively low species diversity and are homogenous (Asher, 2014; Skilton, 2014). They are generally characterised by soft sand/mud substrates that supports mainly polychaete worms, cumaceans, amphipods (small crustaceans), and bivalves (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). They can live for hundreds of years and exist either as individuals or as compact colonies of individual polyps. Deep-sea corals are fragile, sessile, slow-growing and long-lived. They have limited larval dispersal and are restricted to certain habitats. Of the protected marine invertebrate species, the deep sea corals such as black coral and stylasterid hydrocoral (formerly known as red coral), are the most relevant to this MMIA as both groups are protected under the Wildlife Act 1953. NIWA have developed a database of coral distribution around New Zealand based on records from commercial fishing bycatch. From this data the presence of black coral appears to be greatest in the north and east of New Zealand (particularly Chatham Rise). There are no significant densities of black coral or stylasterid coral in the Operational Area (**Figure 12**); however a one-off record of black coral in the South Taranaki Bight was made in 2009, but has not been recorded since.

In addition to corals, 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 a few other 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 12 Distribution of Black Coral (Left) and Stylasterid Coral (Right)



Source: Consalvey et al (2006)

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 productivity of the ocean is the result of many factors; namely ocean currents, climate and bathymetry which cause upwelling and create nutrient rich waters. Such conditions are ideal for the growth of plankton and plankton-consuming animals (MacKenzie, 2014). The semi-enclosed area of the South Taranaki Bight and Western Cook Strait is one of the most biologically productive coastal regions in New Zealand. This productivity is due to various features including the Kahurangi upwelling, sediment discharges from the Kapiti Coast, coastal erosion and surf zone sediment re-suspension, phytoplankton blooms in Tasman and Golden Bays, and energetic mixing of waters in Cook Strait (MacKenzie, 2014).

The Kahurangi upwelling originates off Cape Farewell on the northern South Island coast. The system is described by MacKenzie (2014) and is summarised as follows. The upwelling generates a short and tightly coupled food chain leading from plankton through to higher trophic levels. Cool, nutrient rich waters (from up to 100 m deep) are brought to the sun-lit surface layers via upwelling, resulting in the stimulation of phytoplankton growth. A turbulent wake containing a number of eddies then streams off the Kahurangi Shoals, moving the highly productive plume into the Taranaki Bight and the western approaches of Cook Strait. Zooplankton grazers exploit the increasingly abundant phytoplankton biomass associated with the maturing eddies. As eddies migrate north eastward there are characteristic changes in the species makeup of the zooplankton communities that have important effects on the pelagic food chain (Bradford-Grieve et al., 1993). Of particular importance is *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. (2014) 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 5.2.1.1.1**).

5.3 Coastal Environment and Marine Conservation

5.3.1 Regional Coastal Environment

The Operational Area for the Western Platform Multi-Client 3D Seismic Survey extends over a section of the lower west coast of the North Island. The Operational Area overlaps with the CMA only in the Taranaki region; however, parts of the CMA adjacent to the Operational Area are also discussed below as these regions could potentially be affected in the unlikely event of an oil spill. The CMA associated with the Operational Area is under the jurisdiction of the following local authorities: Waikato Regional Council, Taranaki Regional Council, Horizons Regional Council, Marlborough District Council, Nelson City Council and Tasman District Council (**Figure 13**). The following information is a brief overview of the coastal environment within each region.

The Waikato region is the fourth largest in the country and covers most of the central North Island. The western coast of the Waikato region covers an area from approximately Port Waikato Heads in the north, south to the Mokau River; however it is only the south-western section (from Kawhia Harbour) that is of relevance to this survey. This coast consists of islands, rocky shores and cliffs, coastal lowlands, open coast beaches (particularly black sand beaches), dunes, and estuaries. The western coastline is punctured by three large natural harbours; Raglan, Aotea, and Kawhia (Waikato Regional Council, 2017).

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. Approximately 3.6% of the region's coastline is sand country. 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).

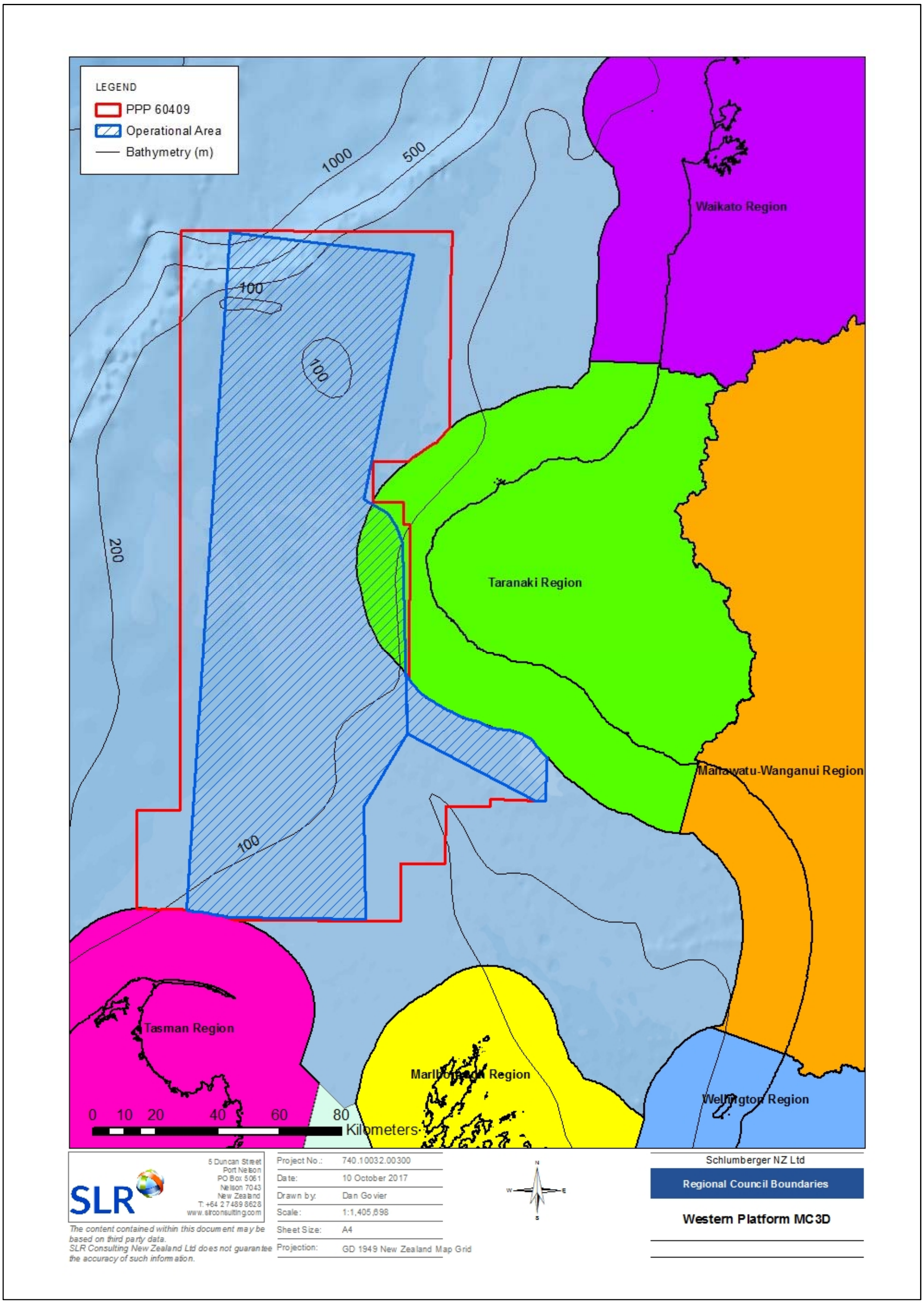
The Marlborough Sounds consists of estuaries and numerous inlets and bays, and includes approximately 1,722 km of coastline. The outer sounds (towards Tasman Bay and of primary interest to the Operational Area) have a varied but mostly rocky coastline interspersed by bays that often contain sandy beaches. Offshore rocky reefs are largely confined to south-west D'Urville Island. Coastal rocky reefs extend out to 6 – 20 m water depth before giving way to coarse gravels and sand, which then becomes soft, sandy muds at greater depths. Most of the coastline is exposed to the north and west; however, a number of sheltered bays and estuaries can be found (Davidson et al., 2011).

The CMA of Nelson includes a very diverse range of habitats. These include estuaries, sandy beaches, boulder banks, spits, sand dunes, salt marshes, sea cliffs, coastal wetlands, and coastal vegetation. The inlets and beaches of Nelson provide sheltered inter-tidal habitat for a range of plant, invertebrate, fish and bird life, while the coastline towards Marlborough is more exposed, and is dominated by coastal cliffs falling to rock and boulder strewn shores and wave-cut reef platforms (NCC, 2004).

Tasman Bay's coast is ecologically diverse and consists of a range of estuary, beach, dune and rocky shore habitats. Estuaries within the region include tidal lagoon and tidal river mouth estuaries, with the most valuable habitats occurring predominantly in the larger tidal lagoon estuaries. Wave dominated tide-modified and tide-dominated beaches occur in this region. Most of the beaches are backed by extensive active sand dune systems that have been colonised by weed species. The structure and composition of Tasman rocky shores vary between sections of the coastline. In the west, shores are high-energy exposed shores with sandstone rock types north of Whanganui Inlet, and mud and sandstone to the south. To the east, in Tasman and Golden Bays, the rock types are variable and include granite, sandstone, mudstone and limestone. The intertidal rocky shore biota of the western coastline is diverse and abundant, with mussels and barnacles dominating. Abundance and diversity is lower in Tasman and Golden Bays, although mussels and barnacles still dominate (Robertson & Stevens, 2012).

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 an oil spill (see **Section 6.3.3**).

Figure 13 Regional Council Boundaries in Relation to the Operational Area



5.3.1.1 Waikato Areas of Significant Conservation Value

Within their Regional Coastal Plan, the Waikato Regional Council has identified a number of Areas of Significant Conservation Value along the region's coastline based on cultural and environmental criteria. Areas of Significant Conservation Value of relevance to the Operational Area are provided in **Table 15**.

Table 15 Areas of Significant Conservation Value in South Waikato

Site	Values
Albatross Point and adjoining coastline	Albatross Point and coastline is of cultural importance to Tainui iwi as a site for gathering kaimoana. It is a haul out and breeding site for New Zealand fur seals. This site is a nationally significant fossil and geological site and contains geo-preservation sites Arataura Point and Ururoa Point.
Kawhia Harbour	Site of immense value to Tainui iwi; commonly referred to as the 'Hearth of Tainui'. Resting site of the canoe Te Ahurei. It contains outstanding habitat for wildlife, wading, shore and wetland birds and extensive eel-grass communities. There are resident and frequenting endangered, rare and threatened birds present. Maui's dolphins occur within the harbour. There are nationally significant fossil sites present.
Marokopa River Estuary	The Marokopa Estuary is a site of cultural importance to Tainui iwi for gathering kaimoana. It supports resident and frequenting rare and threatened wading and coastal bird species, and Maui's dolphins. The estuary contains a number of geo-preservation sites, including Marokopa zeolite facies, Marokopa-Kiritehere coast, and Marokopa River mouth, Triassic-Jurassic contact.
Mokau River Estuary	This site is of cultural importance to Taranaki and Tainui iwi. It provides whitebait spawning habitat that supports a regionally important whitebait and native fishery. Rare and threatened wildlife at this site include resident and frequent visitors such as wading and coastal birds, and Maui's dolphins. The adjoining land is high quality protected riverine habitat.

The Mokau River Estuary lies close to the Waikato/Taranaki Regional boundary and as a result is considered to be a site of cultural importance to both Taranaki and Tainui iwi. It adjoins high quality protected riverine habitat and supports a regionally important whitebait fishery. Rare and threatened wildlife, including waders and coastal birds are residents and frequent visitors to the estuary. Maui's dolphins are occasionally observed in the estuary. There are a number of valued coastal features within the area (Waikato Regional Council, 2005).

5.3.1.2 Taranaki Areas of Outstanding Coastal Value

The Taranaki Regional Coastal Plan is currently under review. Through this section we have included information from the Draft Coastal Plan which is due for implementation early in 2018. Within this draft plan, Taranaki Regional Council have divided the Taranaki coast into five Coastal Management Areas, recognised for their values, characteristics, or uses that are vulnerable or sensitive, or that require different management styles (Taranaki Regional Council, 2016). The Draft Coastal Plan outlines the activities that are permitted to occur within each management area. The five Coastal Management Areas are:

- Outstanding Value Areas: areas that have outstanding natural character and areas identified as outstanding natural features and landscapes. They contain values and attributes (such as landforms, cultural and historic associations, and visual qualities) that are exceptional;
- Estuaries Unmodified: estuaries that have not been significantly modified, including the surrounding area and environment;

- Estuaries Modified: estuaries that are highly modified and are surrounded by urban and extensively modified environments. These estuaries include Patea, Waiwhakaiho and Waitara. Although modified they retain indigenous biodiversity values, amenity values, and contain significant habitats;
- Ports: covers Port Taranaki which contains regionally and nationally important infrastructure; and
- Open Coast: the area within the CMA not covered by other management areas.

The Outstanding Value Areas are further defined as either Areas of Outstanding Natural Value or Areas that are Outstanding Natural Features or Landscapes. **Table 16** and **Table 17** provide details on the relevant coastal features found in these areas.

The Draft Coastal Plan also includes Sites with Significant Amenity Values based on the natural or physical qualities and characteristics that contribute to the pleasantness, aesthetic coherence, and cultural and recreational attributes. These sites are in addition to the Areas of Outstanding Natural Character and Areas that are Outstanding Natural Features or Landscapes and include 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 within the Draft Coastal Plan (Taranaki Regional Council, 2016).

Table 16 Areas of Outstanding Natural Character

Area	Value
Parininihi	Contains unmodified and diverse habitats; coastal forest, dune systems and offshore reefs (unique for North Taranaki). White Cliffs are identified as a well-defined landform of scenic value. The Marine Reserve contains internationally important sponge gardens, high fish diversity and important crayfish and paua habitat. Human activity is minimal giving a high sense of wilderness and remoteness.
Mimi Estuary*	Provides a diverse range of habitat types; riverine estuary, small tidal bays, estuary margins, and sandy foreshore. Supports unmodified natural processes; sand spit and dune processes and river mouth oscillation. Provides important habitats for resident and migratory birds, including threatened species. Contains diverse and regionally distinctive native fish. Human activity is minimal giving a sense of remoteness and high scenic associations.
Paritutu, Ngā Motu (Sugar Loaf Islands) and Tapuae*	Contains a diverse range of habitats; islands and stacks, subtidal canyons, caves, large pinnacles, boulder fields, rocky reefs, and sand flats. The islands have significant scientific and educational value, and support a diverse range and significant number of nesting birds, including threatened species. The Marine Protected Area and Marine Reserve contain a diverse range of fish, sponges, and bryozoans as well as important crayfish and paua habitat. Supports the largest fur seal breeding colony on the North Island's west coast and other marine mammals may be observed at times. Human activity and modification are minimal.
Waikirikiri (Komene Lagoon)	Contains active and uninterrupted natural processes; dune systems, a wide sandy beach that contains an ephemeral wetland and nationally rare coastal habitats. The coastline is accreting (unique for Taranaki). The dune system is unmodified and supports a range of native plants. The wetland and foreshore contains a range of resident and migratory birds including threatened and at risk species. Human activity is minimal, maintaining a high sense of wilderness and remoteness.
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 and at risk plant and animal species are present. It is the migratory route of several bird species. There is minimal modification maintaining strong wild and scenic associations.

Area	**Value**
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 and 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 (see **Table 18**)*	

Table 17 Outstanding Natural Features or Landscapes

Area	**Value**
Waihi Stream to Pariokariwa Point	Contains a sequence of elevated marine terraces dissected by two estuaries, towering coastal cliffs, coastal stacks, islands, caves and arches. Contains several geopreservation sites and the only reef and shore platform north of New Plymouth. Fish breeding grounds are found within the open coastal waters and the Marine Reserve contains significant scientific and ecological values. The estuaries contain important breeding areas for native fish and large shellfish communities. It supports the only mainland nesting site for grey-faced petrel and the offshore stacks and cliff edges also support breeding colonies of a number of other seabirds, including blue penguins. A variety of threatened and at risk plants and animals are present. Aesthetic, scenic and recreational values are very high. Important to tangata whenua and contains significant pā sites and mahinga kai. Historic and archaeological sites are present.
Paritutu, Ngā Motu (Sugar Loaf Islands) and Tapuae*	An area of cultural, historic and spiritual importance to Te Atiawa and Taranaki Iwi due to tangata whenua occupation and use of the area. For ecological values see **Table 16**.
Hangatahuna (Stony River)*	The only braided river within the Taranaki region and the largest and most prominent river flowing to the sea from Mount Taranaki.
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. Is a 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.

Area	Value
North and South Traps*	Popular recreational fishing and diving area and known by local iwi and hapu as a rich fishing ground. See **Table 16** for ecological values.
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 and 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 and 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 (see **Table 18**)*	

In addition to the Areas of Outstanding Natural Value and Areas that are Outstanding Natural Features of Landscapes, a list of coastal areas of local or regional significance in the Taranaki region has been developed by collaboration between Taranaki Regional Council, New Plymouth District Council, South Taranaki District Council and DOC. The resulting areas are considered significant due to their amenity, recreational, cultural/historic and/or ecological/scientific values (Taranaki Regional Council, 2004). Summaries of the areas with a marine component are provided in **Table 18**. Areas already mentioned in **Table 16** and **Table 17** are indicated by an asterisk and are not repeated in **Table 18**.

Table 18 Taranaki Coastal Areas of Local or Regional Significance

Site	Values			
	Amenity	Recreational	Cultural/ historic	Ecological/ scientific
Mokau-Mohakatino (Epiha Reef)	High	Moderate	High	High
Mohakatino Estuary	High	Moderate	High	High
Te Kawau Pa	High	Low	High	Moderate
Te Puia	Moderate	Moderate	High	High
Rapanui	High	Moderate	High	High
Tongaporutu Estuary	High	High	High	High
Tongaporutu Coast	High	Moderate	High	High
Whitecliffs (Parininihi)	High	Moderate	High	High
Pariokariwa Reef and Opourapa Island	High	Moderate	High	Moderate
Pukearuhe	Moderate	Moderate	High	Not known
Waiiti Beach	High	High	High	High
Urenui Estuary and Beach	High	High	High	High
Onaeroa Estuary and Beach	High	High	High	Moderate
Buchanans Bay	Moderate	Moderate	High	High
Motunui Beach	Moderate	Moderate	High	Not known
Waitara Estuary	High	Moderate	High	Moderate
Waitara, Waiongana and Airedale Reefs	High	High	Moderate	Moderate
Waiongana Estuary	High	Moderate	High	High
Bell Block and Waipu Lagoons	High	High	High	High
Waiwhakaiho Estuary	High	High	High	Moderate

Site	Values			
	Amenity	Recreational	Cultural/ historic	Ecological/ scientific
Fitzroy Beach	High	High	Not known	Not known
East End Beach	High	High	High	Not known
New Plymouth Foreshore	High	High	Not known	Not known
Kaweroa Park	High	High	Moderate	Not known
Ngamotu Beach	High	High	High	Moderate
Paritutu/Back Beach	High	High	Not known	Not known
Tapuae Stream Mouth	High	Moderate	High	Moderate
Oakura Beach	High	High	High	Moderate
AhuAhu, Weld and Timaru Road Beaches	High	High	High	Moderate
Tataraimaka	High	Moderate	High	Moderate
Leith/Perth Road Beaches	High	Moderate	High	High
Komene Road Beach	High	High	High	High
Puniho Road Beach	High	Moderate	Not known	Not known
Paora Road Coast	High	High	High	Not known
Stent Road Coast	High	High	High	High
Bayly Road	Moderate	High	High	High
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

5.3.1.3 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 based on their ecological or 'other' (e.g. historic and cultural) important characteristics. These areas are described in **Table 19**.

Table 19 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. 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.

5.3.1.4 Marlborough Ecologically Significant Marine Sites

A large number of sites within the Marlborough marine environment have been identified as ecologically significant as they support rare or special features. Potentially significant sites were initially identified before each site was assessed and ranked based on criteria such as representativeness, rarity (of flora/fauna at the site), diversity (of species and habitats), distinctiveness of any features, size, and connectivity to other significant sites/areas (Davidson et al., 2011). The sites that were assessed to have a 'medium' or 'high' ranking were classified as significant and are further discussed by Davidson et al. (2011).

A total of 129 sites were identified by Davidson et al. (2011) as Ecologically Significant. Due to the extensive number of significant marine sites, not all have been listed in this MMIA, but rather only those closest to the Operational Area in Biogeographical Zone 1 (Croisilles Harbour, Kakaho Point to Current Basin, South-west D'Urville Island to Two Bay Point), and Zone 2 (north-western and eastern D'Urville and northern outer sounds to Cape Jackson), and those with a intertidal or subtidal component have been provided in **Table 20**.

Table 20 Marlborough Ecologically Significant Marine Sites

Ecologically Significant Marine Site	Significance
Biogeographical Zone 1	
Whangarae Estuary	Largest and most natural estuarine in Tasman Bay. Provides habitat for regionally rare species and supports a relatively wide variety of estuarine habitats and associated species.
Croisilles Harbour Entrance	One of the largest and best examples of shallow, tidally swept sand flats in Marlborough. Provides habitat for a variety of species including only known site in Marlborough where the New Zealand lancelet has been recorded.
Motuanauru Island Boulder Bank	Largest single boulder bank habitat in the Marlborough Sounds.
Coppermine and Ponganui Bays	The largest known rhodolith bed in Marlborough and only one in Tasman Bay. Calcified algae play a critical role in the ecosystem by providing additional habitat.
Greville Harbour	Contains good populations of sea sedge (a nationally declining species) at the head of the harbour.
Greville Harbour Channel	Represents fast flow habitat which supports a wide range of species, often in relatively high abundances.
Biogeographical Zone 2	
D'Urville Island Northern Coast	Rocky reef habitats along this coast are characterised by a high diversity of macroalgae, invertebrate, and fish species due to the variety of depths, wave aspects and substrata.
South Arm Port Hardy	Contains the only known location of sea sedge in the northern Sounds biogeographic area and is protected within the D'Urville Island Scenic Reserve.
Offshore Northwest D'Urville Island	Potentially the largest area of bryozoans in the Marlborough Sounds.
Stephens Island (Takapourewa)	Contains outstanding biological values with a large number of rare animals and plants. It is a breeding site for fairy prions, sooty and fluttering shearwaters, diving petrels, blue penguins, and red-billed gulls.
Rangitoto Channels and Passage	Contains high current habitats with a broad coverage of encrusting organisms (sponges, anemones and ascidians). Juvenile fish are abundant in the passages. The northern islands are protected within the Whakatere Papanui Island Recreation Reserve.
Jag Islands	Subtidal reefs support a variety of invertebrates, algae and fish.
Trio Bank	Reef structures support a wide variety of invertebrates and fish.
Penguin Island	One of the best examples of a dense and large dog cockle bed in the biogeographic area. Sooty shearwater and blue penguins nest on the island.
Catherine Cove	One of three sites in Marlborough where rhodoliths are found.
Clay Point	One of the best high-current rocky reef habitats in the northern Sounds biogeographic area with a diverse range of habitats.
French Pass	The best example of a high-current environment in Marlborough and contains a wide variety of habitats.
Admiralty Bay	Contains two areas of biological importance to dusky dolphins.

Ecologically Significant Marine Site	Significance
Paparoa	Contains habitat forming species (bryozoans, sponges, hydroids) on rocky and soft substrate.
Chetwodes	Supports ascidians, hydroids, sponges and bryozoans, with a higher species diversity compared to nearby areas.
Goat Point	Rocky areas are colonised by sponges, anemones, ascidians, corallines, hydroids, bryozoans and tubeworms. A nursery area for fish.
Culdaff Point	Rocky areas are colonised by sponges, anemones, ascidians, corallines, hydroids, bryozoans and tubeworms. One of the few sites of its kind in the northern Sounds biogeographic area.
Allen Strait	The best example in Marlborough of an area dominated by habitat-forming bryozoans. Also important for anemones, hydroids, nesting mussels and colonial ascidians.
Titi Island Mounds	Supports a wide variety of invertebrates and fish in association with bryozoan mounds.
McManaway Rocks	Contains offshore rock stacks which are relatively uncommon in Marlborough and which support unusually high animal diversities.
Witt Rocks	Contains offshore rock stacks which are relatively uncommon in Marlborough which support unusually high animal diversities, particularly fish.
Waitui Bay	Supports horse mussels and associated encrusting species, and a variety of fish including juveniles and commercially/recreationally important species.
Port Gore	Supports a wide variety of habitats and species, including bryozoans and horse mussels.
Gannet Point	Contains colonies of tubeworms (the only known community assemblage of its type in Marlborough). The Gannet Point community is significant at a national level.

Please note that a comprehensive description of all 129 Ecologically Significant Sites for Marlborough can be found in Davidson et al. (2011) which is accessible from the following link: http://www.marlborough.govt.nz/Environment/Coastal/Coastal-Ecosystems/Significant-Marine-Sites.aspx

5.3.1.5 Nelson and Tasman Areas of Significant Conservation Value

There are a number of areas identified as having significant conservation value by both the Tasman District Council and Nelson City Council in their respective Regional Coastal Plans. The areas with an intertidal or subtidal component are provided in **Table 21**.

Table 21 Nelson and Tasman Areas of Significant Conservation Value

Area of Significant Conservation Value	Values
Waimea Inlet	The largest barrier-enclosed estuarine area in the South Island. Retains high biological values despite a high level of human modification. Supports high numbers of wader birds.
Nelson Haven	A large estuarine area that retains relatively high values despite extensive modification. Provides important feeding and roosting areas for wading birds.
The Glen to Cable Bay	Open rocky coastline that represented part of the sequence between exposed marine habitats through to adjacent terrestrial proceed areas. Supports dense populations of ambush starfish and sponge gardens.

Area of Significant Conservation Value	Values
Delaware Inlet/Spit and Pepin Island	Estuary has a low level of human impact; Sand dune forest on the spit is a regionally important feature. Pepin Island is an important roosting site for spotted shag.
Whangamoa Estuary	Relatively unmodified estuary. Supports threatened bird species.
Whanganui Inlet - Westhaven	Protected by a Marine Reserve (Te Tai Tapu) and Wildlife Reserve (Westhaven Wildlife Management Reserve). Provides important breeding and nursery areas for fish and supports more invertebrate species than any other estuary in the South Island. Supports a number of rare and vulnerable birds.
Farewell Spit	A wetland and landform of international importance. Provides feeding ground for 83 species of seabird. The spit is a seabird and wildlife reserve and is kept closed to public except through organised tours.
Golden Bay	Contains 12 areas with nationally important ecosystem values (Puponga Inlet; Pakawau Inlet; Waikato spits, inlet and saltmarsh; Ruataniwha inlet; Parapara inlet and sandspits; Onekaka estuary and sandspit; Onahau estuary; Waitapu estuaries; Motupipi estuary; Tata Beach estuary; Wainui Inlet; and the section of coast between Pohara and Abel Tasman Point). Provides nesting, roosting and feeding habitat for estuarine species and wading birds.
Motueka Deltas	Tidal flats are notable as important wader feeding areas. Attracts over 10,000 birds in late summer.
Moutere Inlet	Notable for the presence of wading birds such as white heron and royal spoonbill.

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.

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, 2017f).

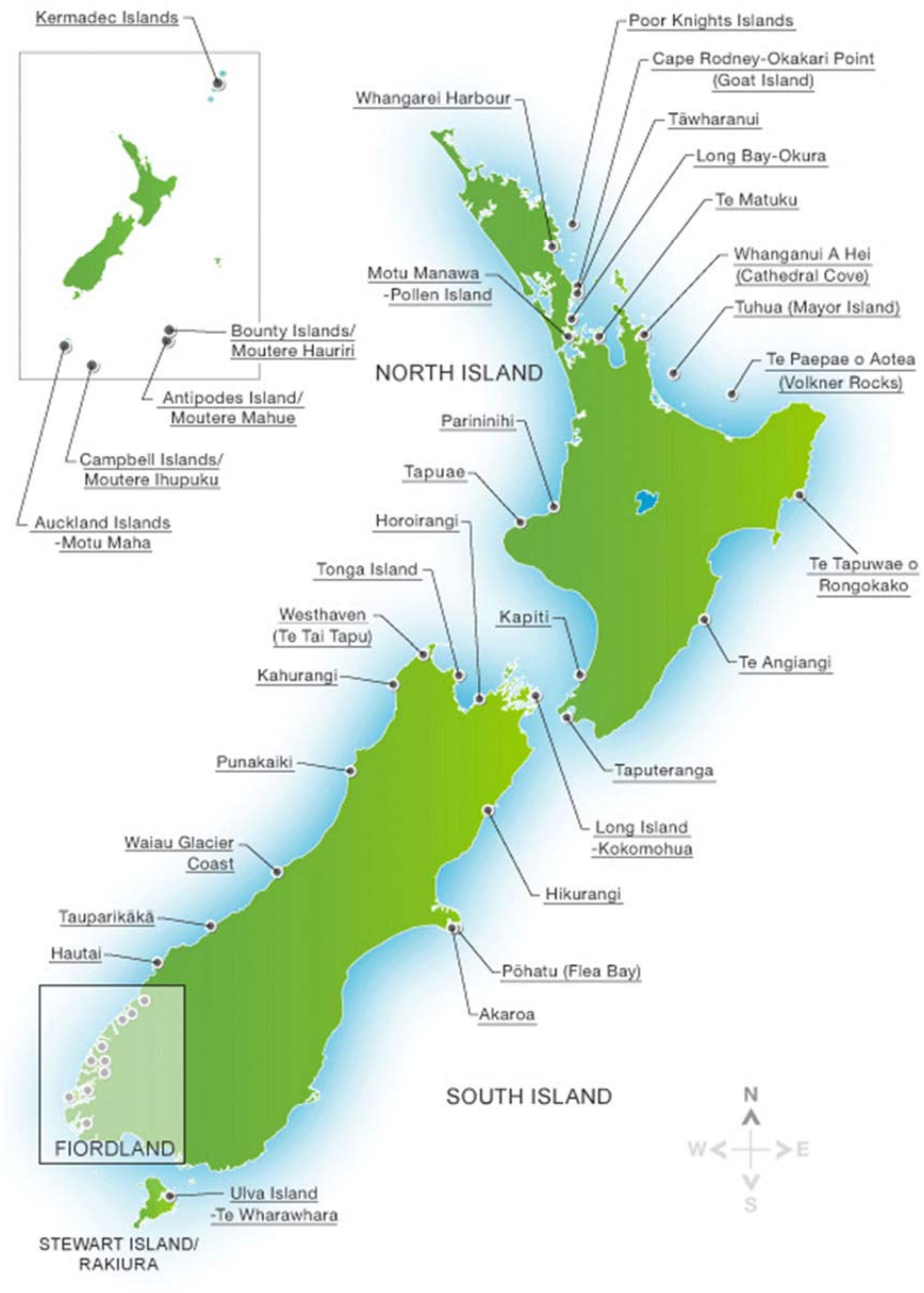
Inshore of the Operational Area are the Parininihi, Tapuae, Horoirangi, Tonga Island, and Westhaven/Te Tai Tapu Marine Reserves, the Sugar Loaf Islands Marine Protected Area (Figure 14) and the West Coast North Island Marine Mammal Sanctuary (

Figure 15).

The Parininihi Marine Reserve covers 1,800 ha of a typical slice of the north Taranaki coastline. The main underwater feature of the reserve is Pariokariwa Reef which extends north from Pariokariwa Point towards the seaward boundary. The reef lies in water depths of five to 23 m and is surrounded by fine sediments and mud. The diversity of encrusting species on the reef is amongst the highest recorded anywhere in New Zealand, including rare and exotic species. A variety of fish and a large rock lobster population is also supported by the reef (DOC, 2017g).

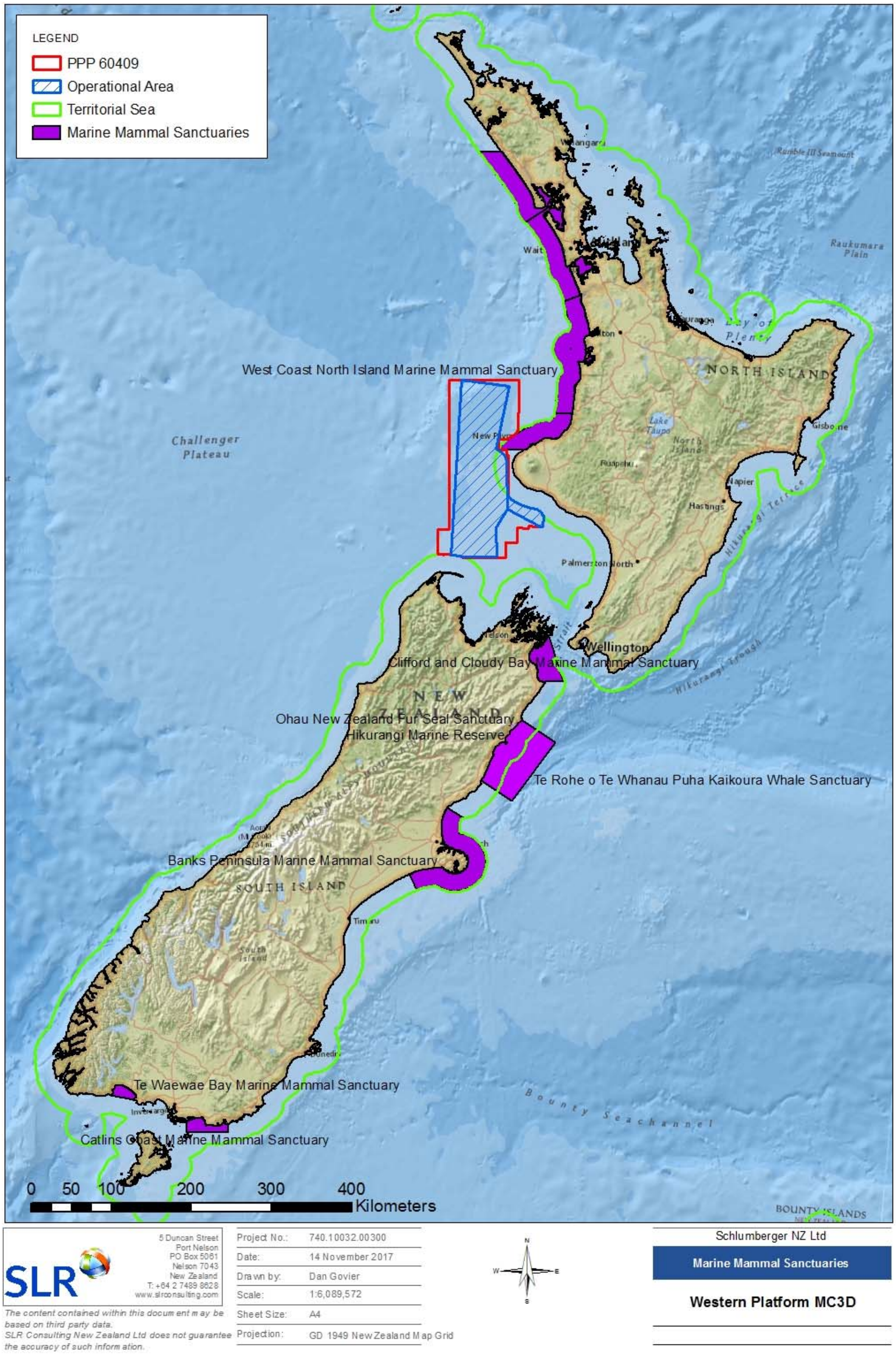
The Tapuae Marine Reserve borders the southern boundary of the Sugar Loaf Islands Marine Protected Area. This Marine Reserve covers an area of 1,404 ha which includes a range of habitats including reefs, mud, sand and boulder platforms as well as both protected and exposed coastline. Around 400 species of fish have been recorded within the reserve, and the substrate is also encrusted with the usual reef species of sponges, shellfish, and bryozoan colonies (DOC, 2017h). Humpback, southern right and killer whales have been observed within the Tapuae Marine Reserve.

Figure 14 New Zealand Marine Reserves



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

Figure 15 Marine Mammal Sanctuaries



The Horoirangi Marine Reserve lies north of Nelson City along the eastern side of Tasman Bay. The reserve extends north-east from Glenduan to the southern headland of Cable Bay (Ataata Point) and offshore for one nautical mile, covering 5 km of coastline and 904 ha (DOC, 2017i). The boulders and bedrock of the reefs within the reserve are the beginnings of the Boulder Bank. The reefs form a wide intertidal zone and extend offshore for up to 400 m to a depth of 20 m (DOC, 2017i). The intertidal and subtidal reefs provide habitat for a range of typical reef animals (shellfish, anemones, sponges, sea squirts, snails, starfish, crustaceans and fish) and are particularly important for ambush starfish. Dense forests of brown seaweeds can be found growing within the reserve. Beyond the reef lie mixes of mud, sand, shelf and gravel (DOC, 2017i).

The Tonga Island Marine Reserve is located in the centre of the Abel Tasman National Park. The boundaries of the Marine Reserve extend from Awaroa Head to the headland immediately north of Bark Bay and offshore to one nautical mile (Davidson & Richards, 2013). It includes the shoreline of all islands and stacks within this boundary, and covers an area of 1,835 ha (Davidson & Richards, 2013). Features within the Tonga Island Marine Reserve include crescent-shaped sandy beaches, rocky headlands and reefs, small estuaries and a sand-mud sea floor (DOC, 2017j). Seaweeds within the reserve are typically confined to a narrow band along the low water mark. Rocky reefs extend to depths of approximately 4 – 14 m and are boarded by gently sloping soft sediment shores (Davidson & Richards, 2013). Fur seals are common within the reserve, especially at breeding colonies on Tonga and Pinnacle Islands (DOC, 2017j).

Westhaven is the first estuary in New Zealand to be protected by a combination of Marine and Wildlife Reserve. The Westhaven/Te Tai Tapu Marine Reserve covers 536 ha of tidal sandflats and channels within the Whanganui Inlet. The reserve is bounded by Melbourne Point and the closest headland of Kahurangi National Park on the opposite shore. It also includes all the tidal areas upstream of causeways along Dry Road, south-west of and including the Wairoa River (DOC, 2017k). The inlet is home to a very high number of invertebrate species which provide a food source for a large number of birds and fish. Approximately 30 species of marine fish use the inlet at some stage and it is an important breeding and nursery area for snapper, flatfish, kahawai, and whitebait. It is the second most important tidal area in the Nelson/Marlborough region for wading birds (DOC, 2017k).

The Ngā Motu/Sugar Loaf Islands Marine Protected Area comprises 749 ha of seabed, foreshore and water around the Sugar Loaf Islands offshore from New Plymouth. Commercial fishing, except trolling for kingfish and kahawai is prohibited within the Protected Area, while recreational fishing is still allowed. The Sugar Loaf Islands are the eroded remnants of a volcano that is characterised by low sea stacks and seven small islands. They provide a semi-sheltered environment on an otherwise exposed coastline, with subtidal habitats such as canyons, caves, rock faces with crevices and overhangs, large pinnacles, boulder fields and extensive sand flats. The predator free islands within the protected area are the only offshore islands in the Taranaki Region and are afforded the status of Wildlife Sanctuary. Nineteen species of seabird are associated with the islands, which provide important nesting habitat for upwards of 10,000 seabirds per year. A breeding colony of New Zealand fur seals also occurs here. At least 89 species of fish, 33 species of encrusting sponges, 28 species of bryozoans and nine species of nudibranchs have been recorded within the Protected Area (DOC, 2017l).

The West Coast Marine Mammal Sanctuary was established in 2008 to protect the threatened Maui's dolphin primarily from fishing impacts. The sanctuary extends alongshore from Maunganui Bluff in Northland down to Oakura Beach, Taranaki. The offshore boundary extends from mean high water springs to the 12 Nm CMA limit. A total of 1,200,086 ha are protected by the sanctuary, covering 2,164 km of coastline. The sanctuary places restrictions on commercial and recreational fishing, with set netting prohibited within 350 km² of the sanctuary (DOC, 2017m). Seabed mining and seismic surveys are also restricted within the sanctuary (see **Section 3.3**). The Operational Area does not enter the West Coast North Island Marine Mammal Sanctuary; however, it comes within approximately 3 km of the sanctuary's offshore southern boundary.

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 mostly of Class 60 and 64 characteristics, with a small extension into Class 63 on the western boundary and Class 22 and Class 55 along the northern boundary (**Figure 16**). These classes are described in further detail below following the definitions by NIWA (Snelder et al., 2005).

Class 22: is in moderately deep waters (mean = 1,879 m) over a latitudinal range from 33 – 38°S. It typically has cooler winter SST and low average concentrations of chlorophyll-α. Characteristic fish within this class include orange roughy, Baxter's lantern dogfish, Johnson's cod and hoki.

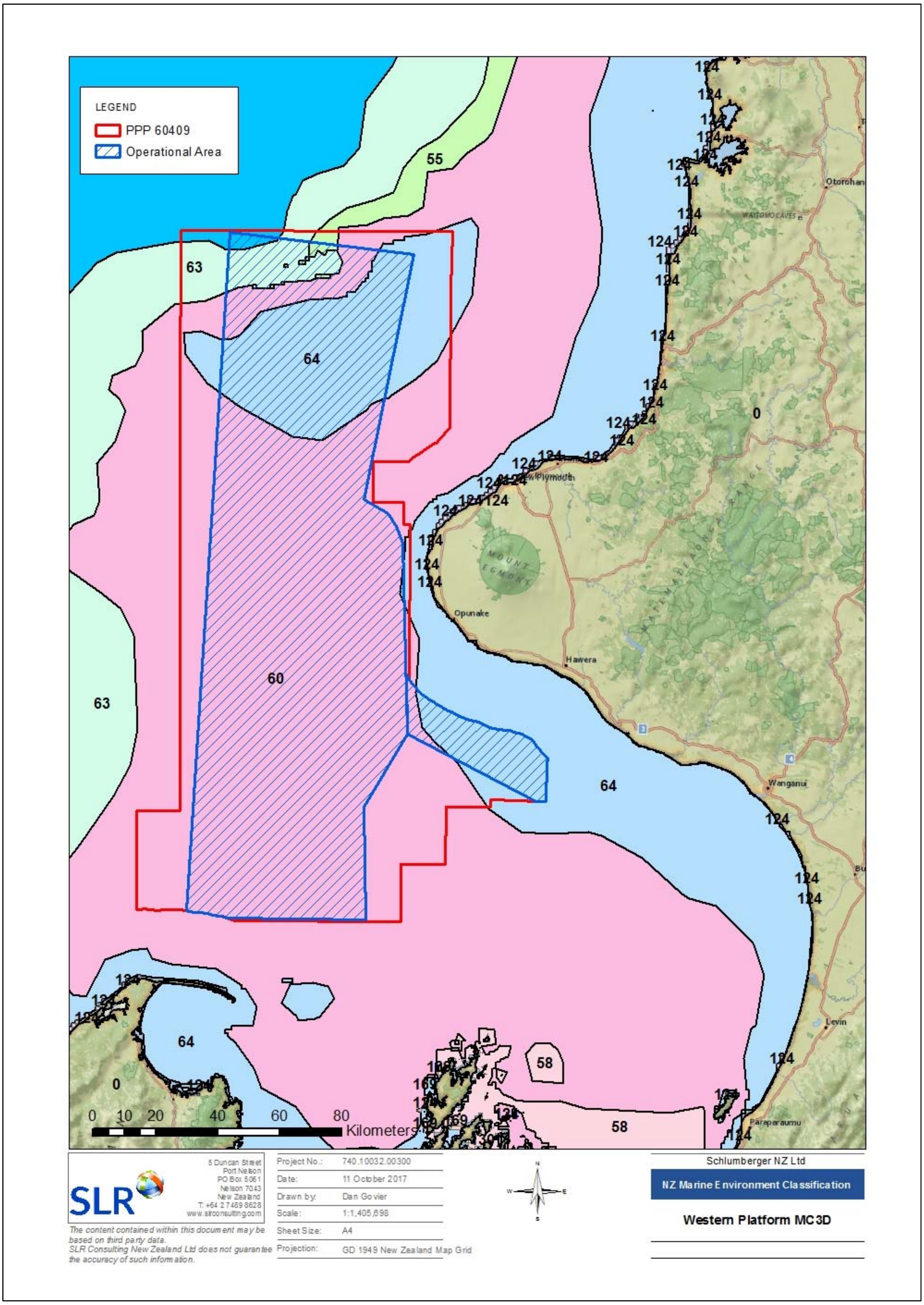
Class 55: occurs at moderately shallow water depths (mean = 224 m) and is of restricted extent, only occurring around northern New Zealand. It has high annual solar radiation, moderately high wintertime SST, and moderate average chlorophyll-α concentration. Characteristic fish species include sea perch, red gurnard, snapper and ling. Arrow squid are frequently caught in trawls. The Dentallidae, Nuculanidae, Pectinidae, Carditidae, Laganidae, and Cardiidae are the most commonly represented benthic invertebrate families.

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 63 is an oceanic, shelf and sub-tropical front environment that is extensive on the continental shelf. Waters are moderate in depth (mean 754 m) and experience moderate annual radiation, wintertime sea surface temperatures and chlorophyll-α concentration. Characteristic fish species include orange roughy, Johnson's cod, Baxter's lantern dogfish, hoki, smooth oreo, and javelin fish. The most commonly represented invertebrate families are Carditidae, Pectinidae, Dentaliidae, Veneridae, Cardiidae, Serpulidae, and Limidae.

Class 64 represents shallow waters (mean = 38 m). Here seabed slopes are low but orbital velocities are moderately high and the annual amplitude of sea surface temperature is high. Chlorophyll-*α* reaches its highest average FIguconcentration 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 16 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 an external factor is more likely to damage a higher proportion of a population or habitat as rarity increases (i.e. a rare habitat has a lower tolerance rating).

Table 22 provides details on the environments considered sensitive under the EEZ Regulations and the indicators used to identify their existence.

Table 22 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; • 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 otherwise homogenic habitats, resulting in modification of the surrounding habitat and communities. 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. Bivalves have been reported to be particularly well represented off the North Island's west coast out to mid-shelf depths (MacDiarmid et al., 2013). Due to their preferred water depths, and the known presence of bivalves in the Taranaki Bight (Johnston, 2016), it is likely that this sensitive habitat will be present in the Operational Area.

The presence of both 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 that are free of fine sediments. While they have been found at all depths, brachiopods tend to prefer water 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., 2016); however, Johnston (2016) has reported one record of brachiopods within 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. New Zealand has a particularly abundant and diverse assemblage of bryozoans (MacDiarmid et al., 2013). Bryozoan thickets have been reported by Johnston (2016) within and in close proximity to the Operational Area.

Calcareous tube worm thickets or mounds can form dense three-dimensional mosaics across the seabed. The mound forming species *Galeolaria hystrix* is the best described example of mounds 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 an important area for calcareous tube worms. Based on the reported literature, calcareous tube worms are unlikely to be present within 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, however, Johnston (2016) reported a number of catches of chaetopteridae tube worms within the Operational Area (off Cape Egmont and within the South Taranaki Bight). Based on the records presented in Johnston (2016), chaetopteridae tube worms are likely to be present within the Operational Area.

The distribution of deep-sea hydrothermal vents is related to plate boundaries. New Zealand deep-sea hydrothermal vents are associated with 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 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). Based on the reported literature and the offshore nature of the Operational Area, it is unlikely that macro-algae beds will be present.

Methane or cold seeps occur when methane-rich fluids escape into the water column from 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) but none have been identified in the Taranaki Basin (Johnston, 2016). Furthermore, it is unlikely that cold seeps will be present within the Operational Area due to the relatively shallow nature of the Operational Area (100 – 200 m).

Rhodolith beds form structurally and functionally complex habitats (MacDiarmid et al., 2013). While little is known of the location of rhodolith beds in New Zealand, known locations are typically coastal in nature (MacDiarmid et al., 2013). The preferred habitats of rhodoliths are 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 (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 been reported as present within the Operational Area (Johnston, 2016).

Sponges are found throughout a variety of environments including shallow coastal rocky reefs, seamounts, hydrothermal vents and oceanic ridges. In New Zealand, demosponges dominate the shelf and coastal area in water depths down to 250 m. 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 its sponge communities (see **Section 5.3.1.2**). Although there is potential for sponge gardens to be present in the Operational Area, all records within Johnston (2016) are for shallow coastal waters.

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 reefs or thickets (MacDiarmid et al., 2013). See **Figure 12** for distribution maps of corals in the Operational Area. Although reported as present within the Operational Area (Johnston, 2016), densities have not been significant.

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 reported a xenophyophore bed offshore of the Operational Area; however, this recording was in water depths in excess of 1,200 m and as such these beds are not expected to be present within the Operational Area.

5.4 Cultural Environment

The marine environment is highly valued by all Māori communities. This value stems in particular from the importance of estuaries and coastal waters as a source of kaimoana (seafood) through both customary and commercial fisheries. In addition to this, the marine environment is also typically regarded as a sacred and spiritual pathway and a means of transport and communication (Nga Uri O Tahinga Trust, 2012). Māori have a deep spiritual connection with whales and dolphins, where whales are thought to provide safety at sea and reportedly guided waka (canoes) on their great journey to New Zealand from the ancestral homelands in the Pacific.

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

Māori first arrived to the Taranaki region between 1250 and 1300 AD. In the early 1800's war parties descended into Taranaki and many people migrated south. The coast the Operational Area is a testimony to this troubled past as it was the scene of many battles and now contains numerous urupa (burial sites). Throughout the region are also many wahi tapu sites, including large pā, tauranga waka, and traditional mahinga kai.

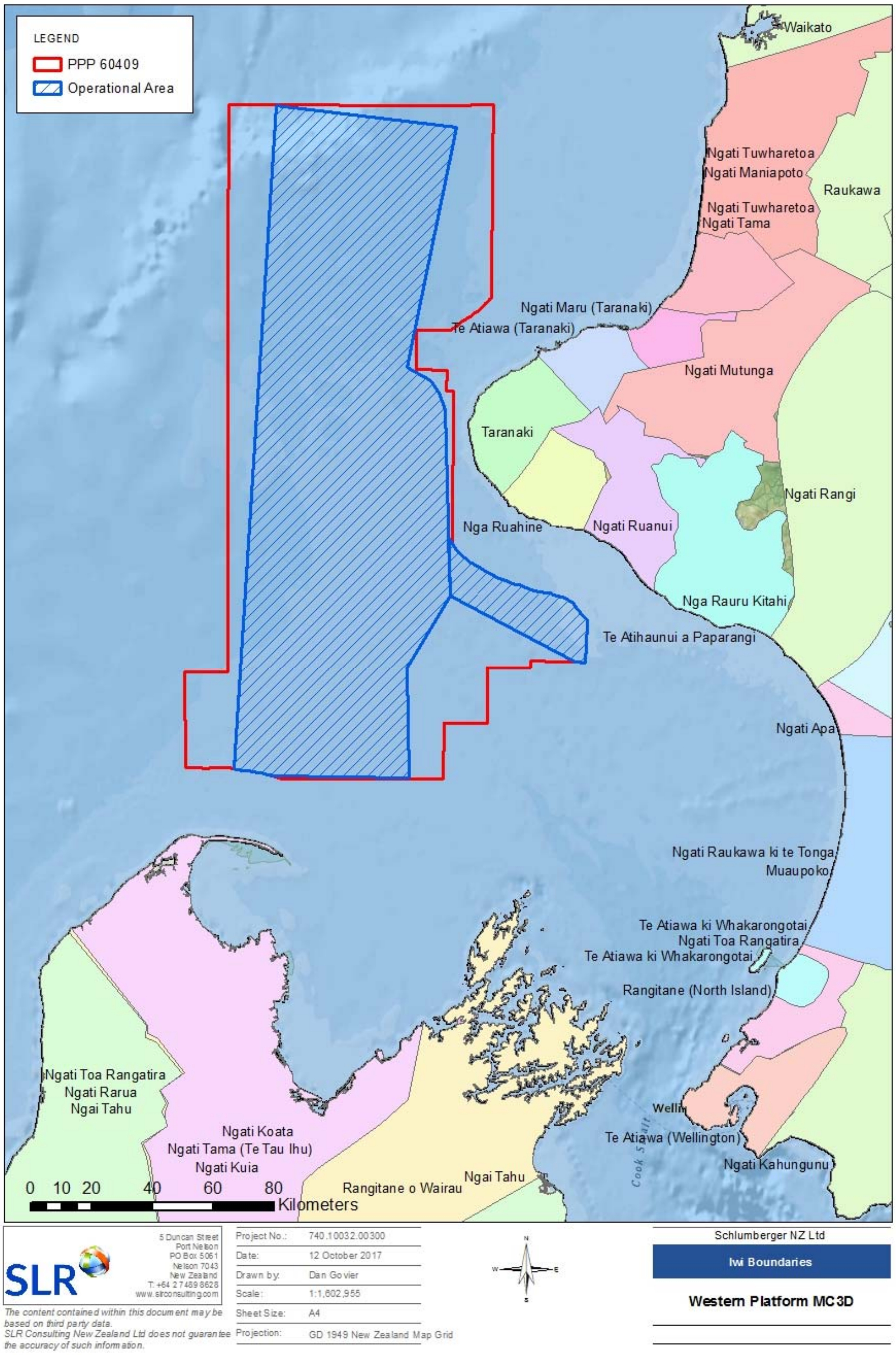
This section provides a brief overview of the iwi (tribes) along the stretch of coastline inshore of the Operational Area (from Mokau to Foxton on the North Island; and from D'Urville Island to Farewell Spit on the South Island) and describes their rohe (area of interest) and any marine attributes of particular cultural interest. The Operational Area is of relevance to seventeen iwi as listed in **Table 23** and depicted in **Figure 17**.

Table 23 Iwi interests in the vicinity of the Operational Area

Iwi (tribal group)	Region/s	Coastal Statutory Acknowledgement Areas	Taonga (treasured) species*	Further comments
Ngāti Maniapoto	Waikato Taranaki	Ngāti Maniapoto have not yet received a historical settlement from the Crown, therefore no statutory acknowledgement rights have been formalised.	Tuna, inanga, paraki (smelt), piiharau (lamprey), kanae, pātiki, kahawai, trevally, tāmure, wheke, koura, kaaeo, kakahi (freshwater mussels), tio, pipi, kina, kuutai (green-lipped mussels), and marine mammals (Tainui Waikato, 2013).	Coastal resources provided and continue to provide sustenance and identity to Ngāti Maniapoto (Tainui Waikato, 2013). Mokau is the resting place for the anchor stone of the ancestral Tainui waka (Kawhia Maori History, 2015). Coastal dunes in the Waikato region contain middens and urupa (Waikato Regional Council, 2015).
Ngāti Tama	Taranaki	Mimi-Pukearuhe coastal marginal strip; Mohakatino coastal marginal strip; and the Coastal Marine Area (CMA) adjoining the rohe.	Traditional kaimoana, e.g. mako, tāmure, and araara (TRC, 2010).	Coastal waahi tapu sites include tauranga waka (canoe berths) and pā sites (Māori villages) at Titooki, Whakarewa, Otumatua and Pukearuhe) (TRC, 2015). A unique fishing technique from the coastal cliffs was developed to catch shark, snapper, and trevally. The Paraninihi Marine Reserve is located within the Ngāti Tama rohe and is managed using an "integrated management approach" which involves Ngāti Tama Iwi Authority alongside DOC and the Paraninihi Marine Reserve Conservation Board.
Ngāti Mutunga	Taranaki	Mimi-Pukearuhe coastal marginal strip; Waitoetoe Beach Recreation Reserve; Onaeroa coast marginal strip; and the CMA adjoining the rohe.	Traditional kaimoana, e.g. mako, tāmure, kahawai and araara (trevally) (Ngāti Mutunga Iwi, 2015).	Ngāti Mutunga has strong cultural, historical and spiritual links to the marine environment. The iwi relies heavily on natural coastal resources as a food supply with kaimoana gathering still occurring in accordance with traditional values and tikanga (teachings). Ngā Mutunga used the cliffs to fish shark, snapper, kahawai, and trevally; these cliffs also hold numerous tauranga waka (canoe berths).
Te Atiawa (Taranaki)	Taranaki	Waiwhakaiho River Mouth; and the CMA from Herekawe Stream to Onaero River.	Traditional kaimoana	Within this rohe lies the Ngā Motu/Sugar Loaf Islands Marine Protected Area. As with all coastal iwi, many heritage features including wāhi tapu and traditional food gathering sites lie along the coastline of this rohe.
Taranaki Iwi	Taranaki	Nga Motu; Paritutu to Oakura River; Oakura River to Hangatahua River; and Kapoaiaia River to Moutoti River.	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.	Traditional kaimoana	Collectively made up of various hapu, including Kanihi-Umutahi, Okahu-Inuawai, Ngati Manuhiaka, Ngati Tu, Ngati Haua and Ngati Tamaahuroa-Titahi.
Ngāti Ruanui	Taranaki Whanganui	Tangahoe River; Patea River; Whenuakura River; and Te Moananui a Kupe o Ngāti Ruanui (the CMA).	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).	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.
Ngā Rauru Kītahi	Manawatu/ Whanganui	Nukumaru Recreation Reserve; Tapuarau Conservation Area; Patea River; Whenuakura River; and Waitotara River.	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 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.
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).	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. The early Māori explorers, Kupe and Tamatea played key roles in the history of this region. The river was an important trade and travel route. Fishing villages were built on the banks of the estuary, with permanent pā sites further up the river.
Te Tai Ihu: Rangitāne, Ngāti Kuia, Ngāti Apa, Ngāti Toa, Ngāti Koata, Ngāti Rarua, Ngāti Tama, Te Atiawa.	Marlborough/ Nelson/ Tasman	Queen Charlotte Sound; Kaka Point; Kaiteriteri; Westhaven; Wharehunga Bay; Separation Point; Port Gore; Farewell Spit; Boulder Bank; Wairau Lagoons; The Brothers; Cable Bay; Tarakaipi Island; Nga Motu Titi; Pelorus Sound; Stephens Island; French Pass; Titirangi Bay; D'Urville Island; Cullen Point; Otuhaereroa Island; Motuanauru Island	Tuangi (cockles), pipi, tuatua, pūpū, kūtai (mussels) and tio (oysters), tāmure (snapper), kanae (mullet), herrings, pātiki (flounder), sole, mango (sharks), kahawai, mackerel, and warehou. Birds (harvested for a range of uses). Whales (harvested for their oil, flesh, bones and teeth). Seals (harvested for their meat and skins) (Te Tau Ihu, 2014).	Estuarine areas were especially prized sources of kaimoana and contained pā, kainga and important fishing stations. Te Tau Ihu depends on the coast for their physical and spiritual wellbeing. Coastal fisheries and other resources were managed by hapū with a kaitiaki role. Matangi Awhio was one of the most important sites in the Nelson area, consisting of a large pā and kainga complex overlooking a beach with safe landing for waka. The Marlborough Sounds formed important trade routes and allowed safe fishing and travel throughout the majority of the year. During travel between the North and South Islands deepwater fish such as ling, hake, and hoki were caught (Te Tau Ihu, 2014).

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

Figure 17 Rohe in the Vicinity of the Operational Area



5.4.1 Customary Fishing and Iwi Fisheries Interests

Kaimoana (seafood) provides sustenance for tangata whenua and an important food source for whānau (family), and is vital for provision of hospitality to manuhiri (guests) (Wakefield & Walker, 2005). 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 value it.

Fisheries assets, including fishing quota, were allocated to recognised iwi throughout New Zealand under the Maori Fisheries Act 2004. Each iwi were also assigned income shares in Aotearoa Fisheries Limited, which is managed and overseen by Te Ohu Kai Moana (the Maori Fisheries Commission).

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

The allocation of customary fishing rights is undertaken by Tangata Kaitiaki/Tiaki in accordance with tikanga Maori. Tangata Kaitiaki/Tiaki are individuals or groups appointed by the local Tangata Whenua and confirmed by the Minister of Fisheries and 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 and do not remove the right of Tangata Whenua to catch their recreational limits under the amateur fishing regulations.

There are three types of customary fishing rights recognised under the legislation: Rohe Moana Mātaitai and Taiapure, The methods of establishment are described below and the locations subject to customary rights are illustrated in **Figure 18**.

5.4.1.1 Rohe Moana

Rohe moana may be established under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 as recognised traditional food gathering areas for which Kaitiaki (customary managers) can be appointed to manage kaimoana collection in accordance with traditional Māori principles. Rohe moana allow for management controls to be established, issuing of permits for customary take, penalties to be established 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. The legally recognised boundaries of rohe moana typically mirror the landward boundary of the CMA. A number of rohe moana occur in the vicinity of the Operational Area as listed below:

- Ngāti kinohaku, Ngāti Te Kanawa and Ngāti Peehi Rohe Moana (lie to the north of the Operational Area);
- 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.

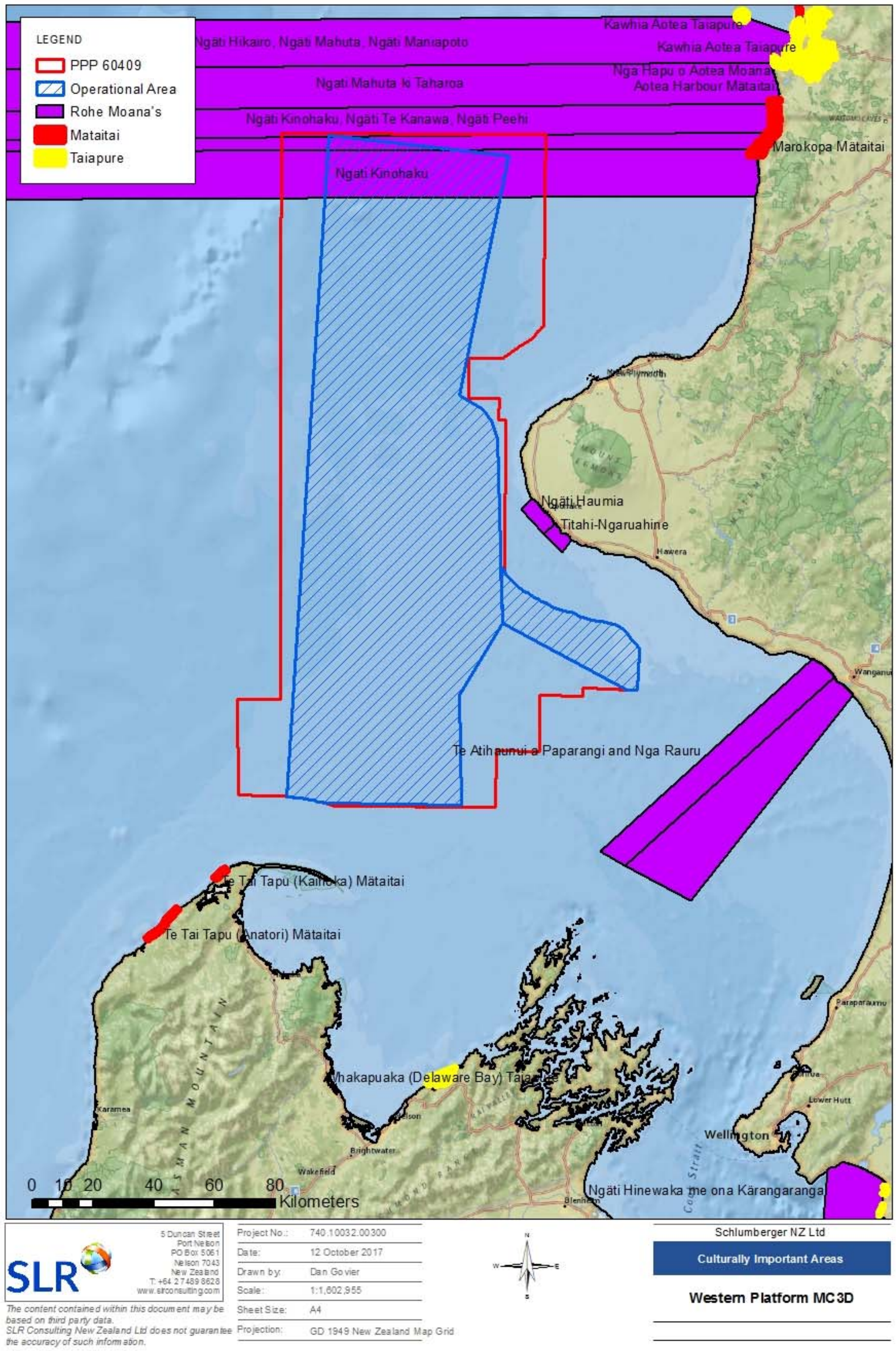
5.4.1.2 Mātaitai Reserves

Mātaitai Reserves recognise traditional fishing grounds and are established to provide for customary management practices and food gathering. Commercial fishing is prohibited within a Mātaitai Reserve; however, recreational fishing is allowed. Tangata whenua are able to establish management areas to oversee fishing within these areas. There are no Mātaitai Reserves in the vicinity of the Operational Area.

5.4.1.3 Taiapure

A Taiapure can be established in an area that has customarily been of significance to an iwi or hapū (sub-tribe) as either a food source or for cultural or spiritual reasons. A Taiapure allows Tangata Whenua to be involved in the management of both commercial and non-commercial fishing in their area but does not stop all fishing. Two Taiapure are located in the vicinity of the Operational Area: Whakapuaka Taiapure, which is located at Delaware Bay (near Nelson) and the Kawhia Aotea Taiapure located at Kawhia.

Figure 18 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

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 24 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 24 Applications under the Marine and Coastal Area (Takutai Moana) Act 2011

Applicant	Region	Recognition Sought	Application Area
Nga Tini Hapu o Maniapoto	South Waikato	Customary Marine Title and Protected Customary Rights	Te Raukumara (north point) south around the Kawhia Harbour to Urawhitiki point west to Honipaka Point (north west point) south to Marokopa thence south to Kiritehere thence to Nukuhakari, thence to Awakino, thence to Mokau, thence to Parininihi – Wai Pingoa stream (south point) including the islands Kaiwhai Island, Te Motu Island, Motukaraka Island, Ngatokakairiri Island, to the outer limits of the territorial sea (eastward and westward)
Nga Hapu o Poutama	North Taranaki	Customary Marine Title and Protected Customary Rights	The area from Onetai in the north to Pukearuhe in the south. This extends out 12 nautical miles between these two points.
Puketapu Whanau (Te Atiawa)	North Taranaki	Customary Marine Title and Protected Customary Rights	The area north east of the Waiwhakaiho river to the mouthe of the Waitara river. This are extends out 12 nautical miles offshore between these two points
Te Atiawa (Taranaki) Iwi	North Taranaki	Customary Marine Title and Protected Customary Rights	Herekawe stream in the south to Te Rau o Te Huia in the north and 12 nautical miles offshore.
Ngāti Mutunga (Taranaki)	North Taranaki	Customary Marine Title and Protected Customary Rights	Titoki Ridge to the Esplanade Reserve out 12 nautical miles
Ngāti Tama	North Taranaki	Customary Marine Title and Protected Customary Rights	From south of Pariokariwa point to the southern bank of the Mokau river out 12 nautical miles
Taranaki Iwi	North and South Taranaki	Customary Marine Title and Protected Customary Rights	Paritūtū to Rawa-o-Turi stream out to 12 nautical miles offshore
Ngāti Ruanui	South Taranaki	Customary Marine Title and Protected Customary Rights	Northern boundary is Waingongoro River, southern boundary is Whenuakura River and out to 12 nautical miles.
Ngā Hapū ō Ngāruahine	South Taranaki	Customary Marine Title and Protected Customary Rights	Between the Taungatara and Waihi Rivers
Ngaa Rauru	South Taranaki	Customary Marine Title and Protected Customary Rights	From Te Awanui-a-Taikehu (Patea River) in the north, then south to the Whanganui River and out to 12 nautical miles.
Ngā Wariki Ngāti Apa	South Taranaki	Customary Marine Title and Protected Customary Rights	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 nautical miles.
Ngāti Hāua Hapū, Ngāruahinerangi Iwi	South Taranaki	Customary Marine Title	Between the mouth of the Raoa (Rawa) stream to the mouth of the Ōtakeho stream to 12 nautical miles.
Rakautaua 9 Whenua Topu Trust	Whanganui	Customary Marine Title	The area from the mouth of the Whangaehu River, south to the mouth of the Turakina River. This area extends out 12 nautical miles offshore between these two points.

Applicant	Region	Recognition Sought	Application Area
Te Awa Tupua and Nga Hapu me Nga Uri o Te Iwi o Whanganui	Whanganui	Customary Marine Title and Protected Customary Rights	Northern Boundary is Kai river to the Southern Boundary which is the Whangaehu river - out to 12 nautical miles.
Te Patutokotoko	Whanganui	Customary Marine Title and Protected Customary Rights	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	Customary Marine Title and Protected Customary Rights	Kaitoke stream to the Whangaehu river and out 12 nautical miles offshore.
Ngati Takihiku, Ngati Hinemata, Ngati Ngaronga	Manawatu	Customary Marine Title and Protected Customary Rights	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. This extends 12 Nautical miles off shore between these two points.
Nga Hapu o Himatangi	Manawatu	Customary Marine Title	The area from the Northern side of Te Puaha o Manawatu to the Southern Side of the Wangaehu awa. The area extends 12 nautical miles off shore between these two points.
Rangitane o Manawatu	Manawatu	Customary Marine Title and Protected Customary Rights	Northern bank of the Rangitikei river to the southern bank of the Manawatu river and out 12 nautical miles between the two points.
Muaupoko	Manawatu	Customary Marine Title	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 nautical miles offshore between these two points.
Te Huria Matenga Trust	Nelson	Customary Marine Title and Protected Customary Rights	The application is for the estuary area of Cable Bay and Delaware Bay (Wakapuaka), Nelson.
Ngati Tama ki Te Tau Ihu	Nelson/Tasman	Customary Marine Title and Protected Customary Rights	The area along the coastline from Kahurangi Point around to Cape Souci out to 12 nautical miles.
Te Atiawa o Te Waka-a-Maui Trust (Mohua/Golden Bay)	Golden Bay	Customary Marine Title	The area from the coastline of Westport, north up the west coast, around Farewell Spit, and along the Golden Bay coastline to Separation Point. The area covers all of the water from the coastline out to the 12 nautical mile extent.
Te Atiawa o Te Waka-a-Maui Trust (Whakatu/Hoiere)	Nelson/ Marlborough	Customary Marine Title	The area from Mapua Point, eastwards along the coastline, around into Te Hoiere/Pelorus Sound and out to the 12 nautical mile area. This includes Rangitoto/D'Urville Island.
Te Atiawa o Te Waka-a-Maui Trust (Mapua)	Nelson/Tasman	Customary Marine Title	The area covers the coastline from Separation Point southwards to Mapua Point and the sea out to the 12 nautical mile extent.
Ngāti Koata	Nelson/ Marlborough	Customary Marine Title and Protected Customary Rights	Surrounding d'Urville Island (out to 12 nautical miles)

5.5 Socio-Economic Environment

5.5.1 Recreational Fishing

The Taranaki Basin Operational Area is not often fished by recreational fishers due to its distance offshore (mostly beyond the 12 Nm CMA). However, the inshore coastline adjacent to the Operational Area in both the North and South Islands support significant recreational fisheries for species such as snapper, kingfish, hapuku/bass, gurnard, trevally, kahawai, tarakihi, blue cod, blue nose, gurnard, paua, mussels, trumpeter, ling, albacore, butterfish, sea perch, kina, blue moki, and crayfish.

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 it is likely that recreational vessels will be in parts of the Operational Area chasing the pelagic game fish.

South of the Operational Area lies the Marlborough Sounds, with the blue cod recreational fishery of particular importance to this area. Recreational fishing in the Marlborough Sounds is concentrated in Queen Charlotte and Pelorus Sounds, as well as around D'Urville Island, with the highest pressure on fish stocks from recreational fishers occurring during summer months due to an influx of visitors (MfE, 2017). The importance of the Marlborough Sounds for recreational fishing is well known and resulted in the proposal of the 'Marlborough Sounds Recreational Fishing Park'. If approved, the Marlborough Sounds Recreational Fishing Park will remain open to recreational fishermen but place restrictions on commercial fisheries (MfE, 2017).

A number of locations within Tasman Bay and the Marlborough Sounds were prized recreationally (and commercially) for their dense, easily accessible scallop beds. Following the results of annual catch surveys showing a decline in scallop biomass and a subsequent complete closure of the fishery in the 2016/2017 scallop season, a second consecutive scallop season closure is in place for the 2017/2018 scallop season (MPI, 2017b).

5.5.2 Commercial Fishing

Ten Fisheries Management Areas (FMAs) have been implemented within New Zealand waters in order to manage the Quota Management System (**Figure 19**). 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 two FMAs: FMA7 (Challenger) and FMA8 (Central) (**Figure 19**).

Finfish species caught within FMA7 and FMA8 are listed in **Table 25**. Here the top five species, according to Total Allowable Commercial Catch (TACC) are presented.

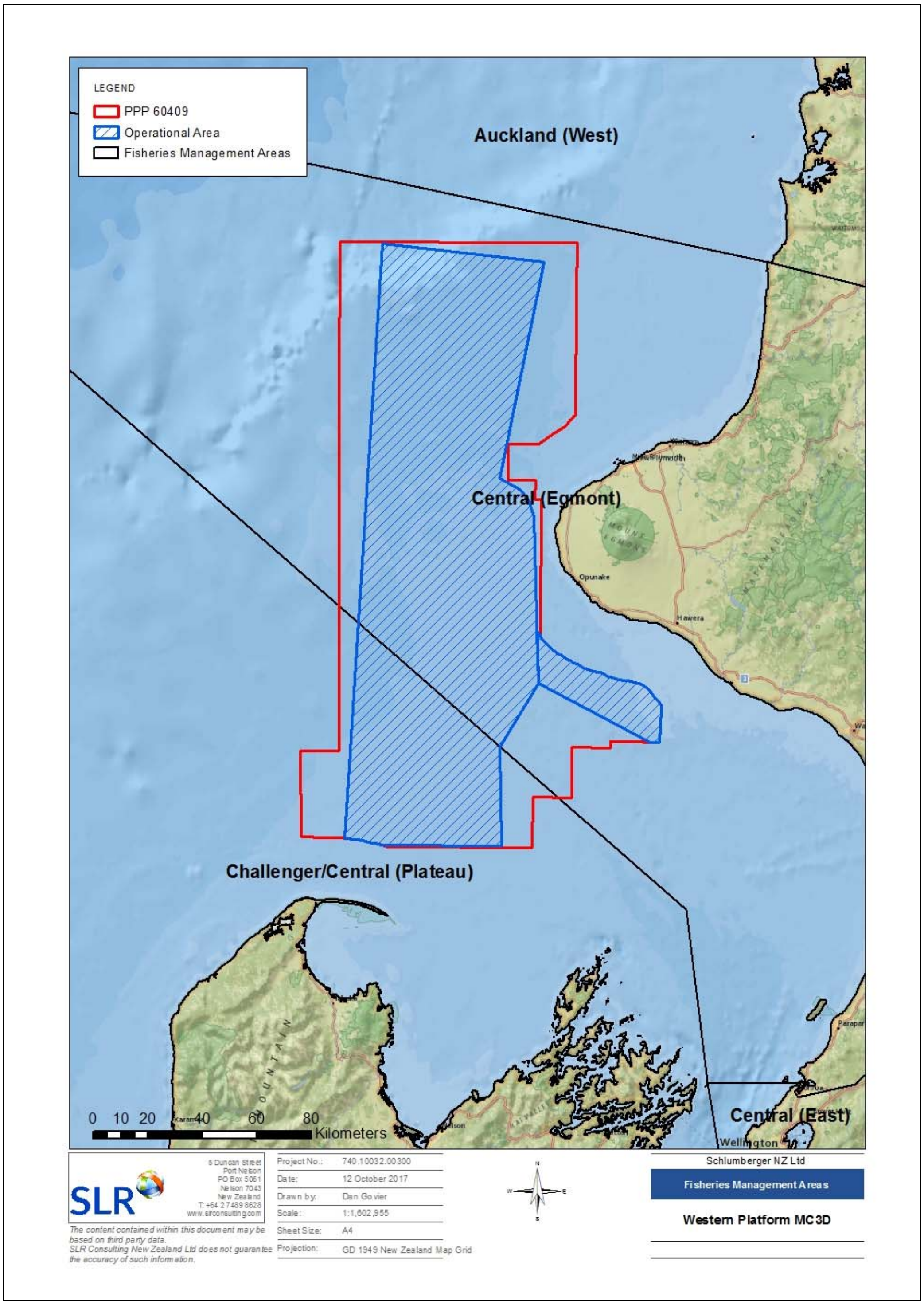
Table 25 Total Allowable Commercial Catch Allocations for Finfish in FMA7/8

FMA7		FMA8	
Species	**TACC (tonnes)**	**Species**	**TACC (tonnes)**
Barracouta	1,1173	Snapper	1,300
Red cod	3,126	Leatherjacket	1,136
Spiny dogfish	1,902	Gurnard	543
Stargazer	1,122	School shark	529
Tarakihi	1,088	Kahawai	520

The primary fishery in the Cape Egmont vicinity is a mid-water trawl fishery for jack mackerel which operates year round, with peaks in catch occurring in October-January and April-July (Gibbs, 2015).

Engagement has taken place with commercial fishers that use the South Taranaki Bight prior to the survey commencing and communication plans will be in place during the survey to minimise any conflict.

Figure 19 Fisheries Management Areas in the Vicinity of the Operational Area



5.5.3 Shipping

Port Taranaki is the closest port to the Operational Area and is situated along the west coast of the North Island, at New Plymouth. Port Taranaki is the only deep water seaport on New Zealand's west coast, with a maximum port draft of 12.5 m. It is a modern port, offering nine fully serviced berths which cater to a wide variety of cargo requirements. Cargo moving through Port Taranaki is typically related to the farming, engineering and petrochemical industries.

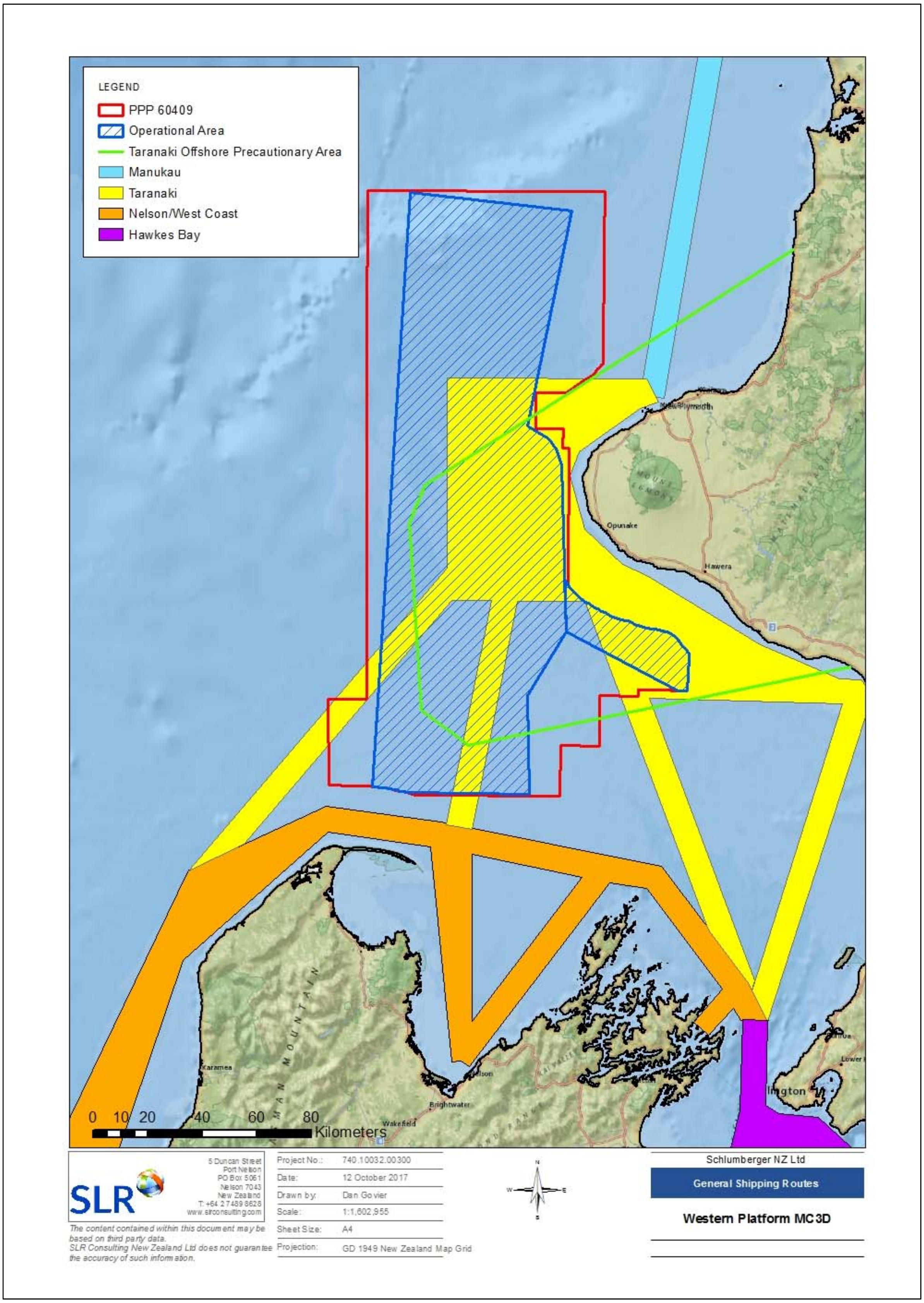
Commercial shipping vessels generally use the most direct path when travelling between ports. There are no dedicated shipping lanes between Port Taranaki and any other New Zealand ports; vessels typically take the shortest possible route. The general shipping routes in the vicinity of the Operational Area are shown in **Figure 20**. The Operational Area is located across the pathway of vessels moving between Port Nelson/Golden Bay and New Plymouth, as well as between west coast ports on the South Island and New Plymouth.

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 Nm clear of the installation.

A Precautionary Area was established in offshore Taranaki (**Figure 20)** 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 5.5.4**).

Figure 20 General Shipping Routes Surrounding the Operational Area



5.5.4 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 21**). 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 Maari Oil Field is located within the Operational Area, towards the south. It covers 34 km^2, and is New Zealand's largest discovered crude oil field. Commercial production of light crude oil did not occur until February 2009, despite the discovery of Maari in 1983. The Maari Oil Field consists of two producing fields (Manaia and Matariki), the platform Tiro Tiro Moana, the Floating Production Storage and Offloading (FPSO) vessel the 'Raroa', and associated subsea connecting pipelines (Offshore Technology, 2017).

The Māui Oil Field lies within the Operational Area and covers 157 km^2, with targeted reserves 3,000 m below the sea bed. When first discovered in 1969 by Shell, BP and Todd Petroleum, Māui was considered one of the largest oil discoveries in the world. Infrastructure at Māui consists of two platforms (Māui-A and Māui-B) and subsea pipelines. Māui-A was installed in 1977, with full production commencing in 1979. The platform is connected to the shore-based Māui Production Station at Oaonui, where condensate is treated and the LPG and associated gasses are removed. Māui-B lies 15 km from Māui-A and was installed in 1992 to allow full drainage of hydrocarbons from the field, and to allow production from deeper reserves. The FPSO 'Whakaaropai' originally stored gas and condensate from Māui-B, however since the FPSO's decommissioning in 2006, all products from Māui-B have been transported to Māui-A through subsea pipelines (STOS, 2017).

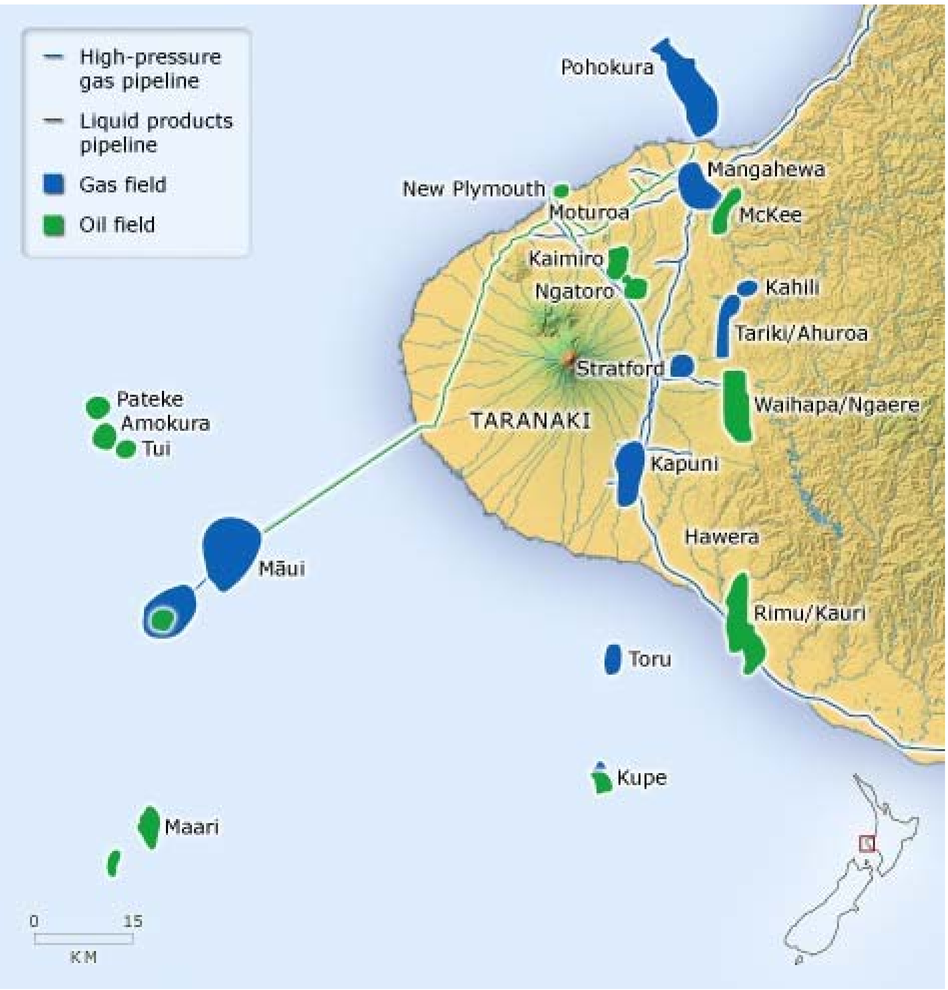
The Kupe Gas and Light Oil/Condensate Field lies outside of the boundaries of the Operational Area in the South Taranaki Bight. The field was discovered in the mid-1980s, however at this time it was considered to be sub-commercial. Interest in the Kupe field picked up again in the early-2000's with a 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 from the Kupe Field are transported to the onshore production station, where raw gas is processed to meet specifications for the New Zealand LPG market (NZOG, 2017). The Kupe Platform and associated pipelines are protected by the Submarine Cables and Pipelines Protection (Kupe Gas Project) Order 2008. The Kupe Field is operated by Origin Energy, with Genesis and New Zealand Oil and Gas joint venture partners (Oil & Gas Journal, 2017). The tie line into the eastern extension of the Operational Area will correlate historical seismic data collected from around the Kupe Field with contemporary data collected during the current survey.

The Pohokura Gas Field lies in water depths of 50 m northeast from New Plymouth and is New Zealand's largest gas resource (STOS, 2017a). It covers an area 16 km long and 5 km wide, at about 3,600 m below the seabed (Offshore Technology, 2017a). The gas field is jointly owned by Shell, Todd Pohokura Limited and OMV New Zealand Limited, with STOS operating the field on behalf of the joint venture partners. Production of gas from this field commenced in September 2006 with the commissioning of three onshore wells, and offshore condensate and gas production commenced in March 2007. Gas and condensate produced from the offshore wells flows to the onshore production station at Motunui via undersea pipelines. The Motunui production station separates the condensate from the gas flow, which is then piped to the Omata Tank Farm before being transported to the Marsden Point refinery (STOS, 2017a). The Pohokura Gas Field lies inshore of the Operational Area.

The Tui Area Oil Project began producing in 2007 and consists of three fields; Tui, Amokura, and Pateke. Produced oil is transported to, and stored on, the FPSO 'Umuroa' (AWE, 2017). In November 2016 Tamarind took over sole ownership of the Tui Area Oil Project from AWE (Offshore Technology, 2017a).

A simultaneous operation plan will be in place for the duration of the survey and Schlumberger has engaged with all the offshore operators to understand what activities will be taking place within each field durng the survey period. This will ensure there is minimal conflict during the survey.

Figure 21 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 Western Platform Multi-Client 3D 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 using a risk matrix to identify the significance of each potential effect based on a likelihood and consequence approach (**Table 26**). The joint Australian & New Zealand International Standard Risk Management – Principles and Guidelines, (AS NZS ISO 31000:2009) (ISO, 2009) has been used to develop the ERA. These guidelines define risk as 'the uncertainty upon objectives', while the effect is a deviation from the expected – either positive or negative. This assessment considers the consequence (**Table 27**) and likelihood (**Table 28**) of each potential environmental effect, including its geographical scale (site, local and regional) and its duration. A description of the risk matrix categories is provided in **Table 29.**

The predicted effect in the ERA matrix 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 are:

- Identification of the sources of potential effects;
- Description of potential effects;
- Identification of potential environmental receptors and their sensitivity to potential effects;
- Development of measures to avoid, remedy or mitigate each potential effect; and
- Determine the risk associated with any residual effects (in accordance with **Table 26, Table 27** and **Table 28**).

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

Table 26 Environmental Risk Assessment

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

Table 27 Consequence Definitions for Residual Effects

Consequence level	**Underwater noise** (following the exposure criteria proposed in Southall et al., 2007)	**Populations** (adapted from MacDiarmid et al., 2012)	**Magnitude & Recovery Period** (adapted from MacDiarmid et al., 2012)	**Proportion of habitat affected** (adapted from MacDiarmid et al., 2012)	**Existing Interests (fisheries – commercial or recreational, cultural, social, shipping etc.)**[1]
4 - Catastrophic	Significant numbers of marine mammals exposed to SELs greater than 218 dB re $1\mu Pa^2.s$ (could elicit permanent threshold shift)	Severe impact to communities and populations. Local extinctions likely.	Large scale effect (10-100 km^2). Long term duration (years). No recovery predicted	Activity will result in major changes to ecosystem or region. Virtually all available habitat is affected.	Long term and wide scale disruptions to normal activities.
3 - Major	Individual marine mammals exposed to SELs greater than 218 dB re $1\mu Pa^2.s$ (could elicit permanent threshold shift)	Long-term impact to communities and populations. Threatens long-term viability.	Large scale effect (10-100 km^2). Long term duration (years). Substantial recovery period required once activity stops (more than a month).	Activity may result in major changes to ecosystem or region; 60-90% of habitat affected.	Long term disruptions to normal activities.
2 - Moderate	Individual marine mammals exposed to SELs between 186 and 218 dB re $1\mu Pa^2.s$ (could elicit temporary threshold shift)	Medium-term impact to communities and populations. Could affect seasonal recruitment, but does not threaten long-term viability.	Medium scale effect (1-10 km^2). Medium term duration (weeks-months). Short term recovery period required once activity stops (days to weeks).	Potential adverse effects more widespread; 20-60% of habitat is affected.	Medium term disruptions to normal activities.
1 - Minor	Marine mammals exposed to SELs between 171 and 186 dB re $1\mu Pa^2.s$ (could elicit a behavioural response)	Short-term impact to communities and populations. Does not threaten viability.	Localised effect (<1 km^2). Short term duration (weeks). Rapid recovery would occur once activity stops (within hours-days).	Measurable but localised; potential effects are slightly more widespread; 5-20% of habitat area is affected.	Short term disruptions to normal activities.
0 – Negligible	Marine mammals exposed to SELs less than 171 dB re $1\mu Pa^2.s$	No detectable adverse effects to communities or populations.	Highly localised effect (immediate area). Temporary duration (days). No recovery period necessary	Measurable but localised, affecting 1-5% of area of original habitat area.	No disruptions to normal activities.

[1] Consequence levels for existing interests were developed by SLR Consulting Ltd to augment those categories already defined for ecological parameters.

Table 28 Definition of 'Likelihood' for Residual Effects

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

Table 29 Risk Category Definitions for Residual Effects

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

6.2 Planned Activities

6.2.1 Physical presence of seismic vessel and towed equipment

The physical presence of the seismic vessel, the support vessel, and associated acoustic equipment may cause some environmental impacts and may also affect cultural, commercial, and social values. Each potential effect is discussed below.

6.2.1.1 Potential effects on marine mammals

Vessels share the marine environment with marine mammals; hence vessel presence has the potential to:

- Disrupt normal marine mammal behaviour;
- Displace marine mammals from areas of habitat;
- Result in a ship strike between a mammal and vessel; and
- Create entanglement risks to marine mammals from towed equipment.

Disruption of normal animal behaviour and displacement is of particular concern when it occurs frequently or over a prolonged period and affects critical behaviours such as feeding, breeding and resting. It is possible that the physical presence of the survey vessels and associated acoustic equipment could cause some temporary and localised changes in marine mammal behaviours and/or displacement from habitat. Marine mammals show two main stereotypical behaviours in the presence of vessels; avoidance or attraction (Wursig et al., 1998), both of which can affect energy expenditure and disrupt natural behaviour. Avoidance most commonly leads to an animal becoming temporarily displaced from an area, which is of concern when this displacement occurs over prolonged periods and/or affects critical behaviour. However, such disturbance is predicted to be temporary due to the limited duration of operational activities. Furthermore, marine mammals must be in relatively close proximity to the vessels and equipment in order to be affected by their presence.

Ship strike (the collision between a marine mammal and a vessel) is of global concern. Jensen and Silber (2004) reviewed the global database of ship strike incidents and considered a total of 292 records of ship strikes to large whales. The findings of this study reported that fin whales (75 records) and humpback whales (44 records) were the species most commonly involved in ship strike incidents. Other high risk species included minke whales, southern right whales and sperm whales. Of these high risk species, minke whales, southern right whales and sperm whales are considered ‘likely’ to be present in the Operational Area, while fin and humpback whales could be present from time to time as ‘occasional visitors’.

Jensen and Silber (2004) also demonstrated that vessel type plays a role in the likelihood of mortality. The majority of fatal strikes were caused by navy vessels and container/cargo ships/freighters. Seismic vessels (categorised in the study as ‘research’ vessels) accounted for only one ship strike incident.

The faster a vessel is travelling, the greater the likelihood of mortality from ship strike. Jensen and Silber (2004) reported a mean speed of 18.6 kts for vessels involved in lethal ship strikes. During acquisition, seismic vessels typically only travel at ~4.5 kts; less than four times slower than the mean fatal speed reported by Jensen and Silber (2004). Records of sub-lethal effects are less reliable on account of the difficulty in assessing injury in free swimming cetaceans following a collision. In New Zealand waters, ship strike is a particular concern for Bryde’s whales in Hauraki Gulf. Riekkola (2013) reported that a reduction in vessel speed in the Hauraki Gulf from 13.2 to 10 knots could reduce the likelihood of lethal injury in any ship strike incident from 51% to 16%.

Although marine mammals could interact with and become entangled in towed seismic equipment, it is highly unlikely that this would occur on account of marine mammals displaying exceptional abilities to detect and avoid obstacles in the water column and there being no loose surface lines associated with the towed equipment (Rowe, 2007). Unlike interactions with fishing gear, there is no food attractant associated with seismic surveys. To our knowledge, there has never been a reported case of a marine mammal becoming entangled in seismic equipment.

During the Western Platform Multi-Client 3D Seismic Survey and in accordance with the Code of Conduct, MMOs will be on-watch during daylight hours for all periods of acquisition. In addition to this and during good sighting conditions, at least one MMO will be stationed on the bridge during transit to and from the Operational Area to maximise the data collected about marine mammal distribution during the survey. The protocol that MMOs will follow during the Western Platform Multi-Client 3D Seismic Survey is outlined in the Marine Mammal Mitigation Plan (MMMP) which is included as **Appendix D**. MMOs will be briefed specifically to be vigilant for entanglement incidents associated with the towed acoustic equipment, and they will also be expected to report any dead marine mammals observed at sea, and to notify DOC immediately should any live sightings of Maui's or Hector's dolphins be made. Weekly MMO reports will be provided to DOC and the EPA.

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 Western Platform Multi-Client 3D Seismic Survey is ***medium*** (minor × likely).

6.2.1.2 Potential effects on seabirds

As a result of the high numbers of seabirds potentially present within the Operational Area (see **Section 5.2.3**), it is likely that encounters between seabirds and the seismic vessel will occur during the Western Platform Multi-Client 3D Seismic Survey. Seabirds frequently interact with vessels at sea; many such interactions result in harmless behavioural changes (i.e. birds using vessels as perching opportunities that would otherwise not be available), while other interactions can lead to injury or death (i.e. collision or entanglement in vessel rigging, especially at night). Disorientation of seabirds at night can occur as a result of artificial lighting; particularly for fledglings and novice flyers in coastal locations (Telfer et al., 1987). Artificial lights possibly increase the risk of collision with vessels (Black, 2005).

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

No specific mitigations are in place to reduce the likelihood of seabirds colliding with the seismic vessel, but the surveys vessels confer no greater collision threat to seabirds than any other vessel would, and the slow operational speed of the vessels most likely reduces this potential. The relatively short term duration of the survey also limits the temporal scale of effects and no population level effects are predicted.

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

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

6.2.1.3 Potential effects on other marine users

There is potential that the Western Platform Multi-Client 3D Seismic Survey could interfere with fishing activities by causing a temporary displacement of fishing operations whilst the seismic vessel and towed equipment passes through the various fishing grounds in the Operational Area. Seismic data acquisition could also cause displacement of fish stocks; however, the short term nature of operations will ensure that such effects are strictly temporary.

Commercial fishers will be advised of the proposed operations and will be kept informed with regard to start dates and scheduling as well as being provided with a 48 hour look ahead for survey operations every 24 hours. It is assumed that any effect on fisheries (displacement of vessels and fish stocks) is likely to be temporary; however, to ensure that the potential environmental effects are minimised, Schlumberger will:

- Operate 24 hours a day, 7 days a week (weather and marine mammal encounters permitting) to minimise the overall duration of the survey;
- Comply with the COLREGS (e.g. radio contact, day shapes, navigation lights, etc.);
- Notify commercial fishers of the proposed survey and provide a 48 hour look ahead of operations every 24 hours;
- Have a support vessel present;
- Issue a Notice to Mariners and a coastal navigation warning; and
- Display a tail buoy at the end of the streamer to mark the overall extent of the towed equipment.

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

6.2.2 Acoustic disturbance to the marine environment

Low frequency sound sources, such as those produced during a marine seismic survey, are directed downwards towards the seafloor and propagate efficiently through the water with little loss from attenuation (absorption and scattering). Attenuation depends on propagation conditions; in good conditions, background noise levels may not be reached for >100 km, while in poor conditions background levels can be reached within a few tens of kilometres (McCauley, 1994).

Upon activation of an acoustic source, most of the emitted energy is of low frequencies (0.01 – 0.3 kHz); however, pulses also contain higher frequencies (0.5 – 1 kHz) in small amounts (Richardson et al., 1995). The low frequency component of the sound spectrum attenuates slowly, while the high frequency component rapidly attenuates to levels similar to those produced by natural sources.

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

Generally speaking, a high intensity external stimulus such as an acoustic disturbance will elicit a behavioural response in animals; typically avoidance or a change in behaviour. The duration and intensity of an animal's observed response is impacted by the nature (continuous or pulsed), source (visual, chemical or auditory) and the intensity of the stimulus, as well as the animal's species, gender, reproductive status, health and age.

Behavioural responses are instinctive survival mechanisms that serve to protect animals from injury. Consequently, animals may suffer temporary or permanent physiological effects in cases when the external stimulus (e.g. acoustic disturbance) is too high or the animal is unable to elicit a sufficient behavioural response (e.g. swim away fast enough). Temporary or permanent physiological effects may also be incurred due to a behavioural response (e.g. getting the “bends” from swimming quickly to the surface). Limited evidence suggests this might actually be the greatest risk of injury for some species (e.g. Fahlman et al., 2014).

Depending on the exposure level and sensitivity threshold of each species, the effects of acoustic disturbance can include:

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

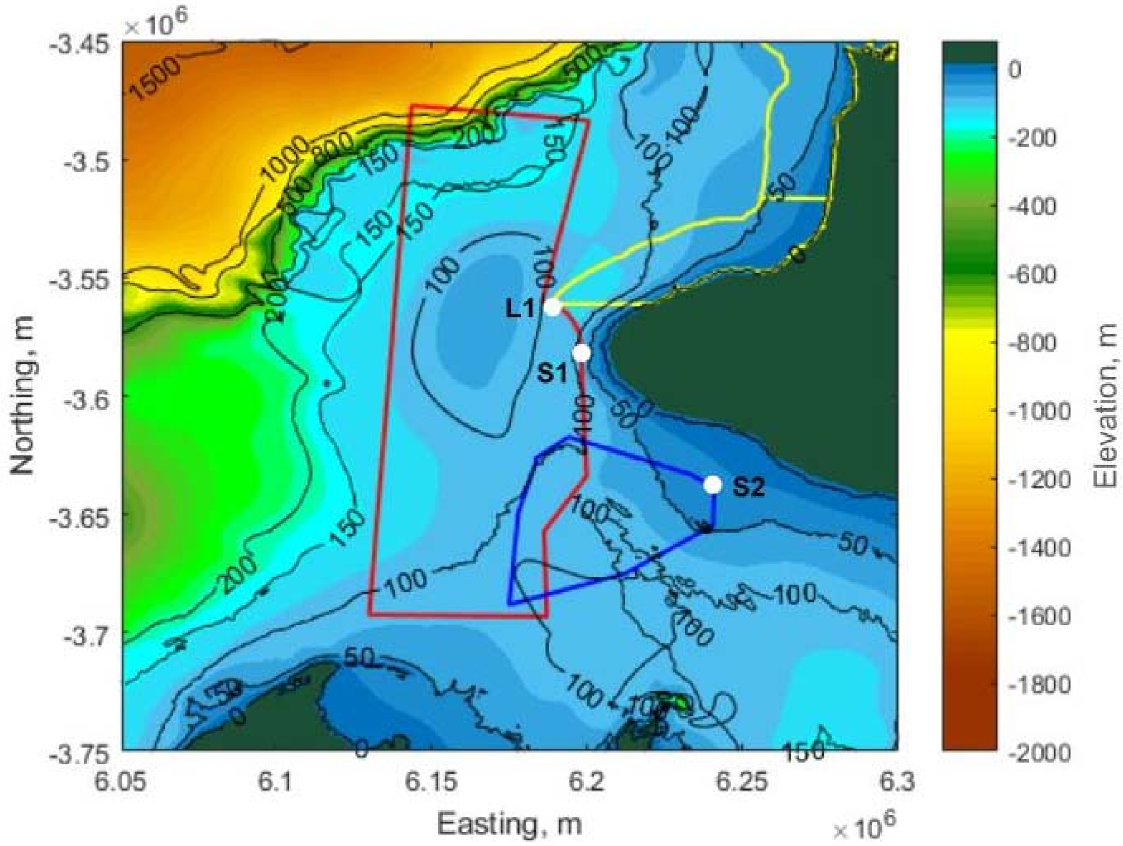
The Code of Conduct was developed specifically to minimise the potential effects on marine mammals of acoustic disturbance (both behavioural and physiological) from seismic surveys. Compliance with the Code of Conduct represents the primary way in which Schlumberger will manage the potential effects of acoustic disturbance during the Western Platform Multi-Client 3D Seismic Survey; however, mitigations over and above those required by the Code of Conduct will also be adopted.Potential acoustic exposure of marine fauna during the Western Platform Multi-Client 3D Seismic Survey was assessed by way of STLM. STLM uses input parameters specific to the source array, and bathymetry and geological data specific to 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

SLR undertook STLM to predict received Sound Exposure Levels (SELs) from the Western Platform Multi-Client 3D Seismic Survey to assess for compliance with the mitigation zones in the Code of Conduct (short-range modelling) and for far-field propagation (long-range modelling). The modelling methodology addresses both the horizontal and vertical directionality of the acoustic array and considers the different water depths and substrate types found throughout the Operational Area. The complete modelling report is provided in **Appendix A** and the results are summarised here.

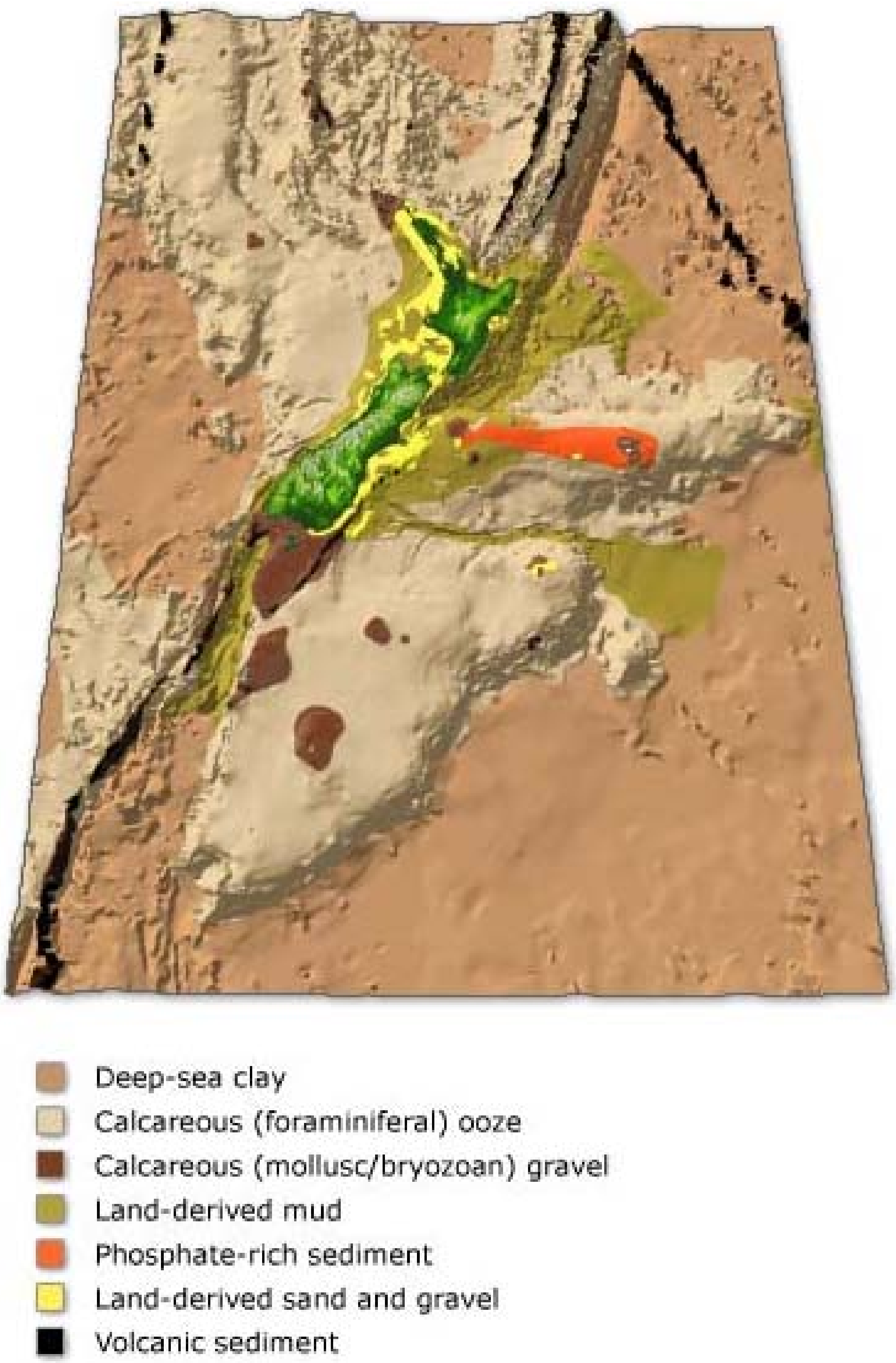
Two source locations were selected for short-range modelling (S1 and S2) and one source location was selected for long-range modelling (L1) (**Figure 22**). The two short range modelling locations represent the shallowest water depths within the Operational Area (S1 = 80 m in the main acquisition area, S2 = 30 m in the eastern tie line extension); and the long-range source location was selected based on its proximity to the North Island West Coast Marine Mammal Sanctuary, its reasonably shallow water depth (109 m) and the clear propagation pathways north and south. It is important to note here that the long-range source *modelling* location lies closer to the sanctuary boundary (due to modelling worst case scenario) than the actual survey lines which, at their closest point, sit 8.5 km from the sanctuary boundary. Therefore SELs occurring at the sanctuary boundary during the Western Platform Multi-Client 3D Seismic Survey will be lower than those predicted by the STLM.

Figure 22 Modelling Locations for the Taranaki Basin Operational Area



The Operational Area is large and encompasses a range of bathymetry. The Continental Shelf around New Zealand is covered mainly with land-derived sand, gravel and mud sediment (**Figure 23**). In order to predict the highest SELs possible during the Western Platform Multi-Client 3D Seismic Survey, the most reflective (worst case) substrate was used for the purposes of modelling. For all modelling locations a fine sand seafloor was used. A summer sound speed profile was used for the modelling based on the summer scheduling for this survey.

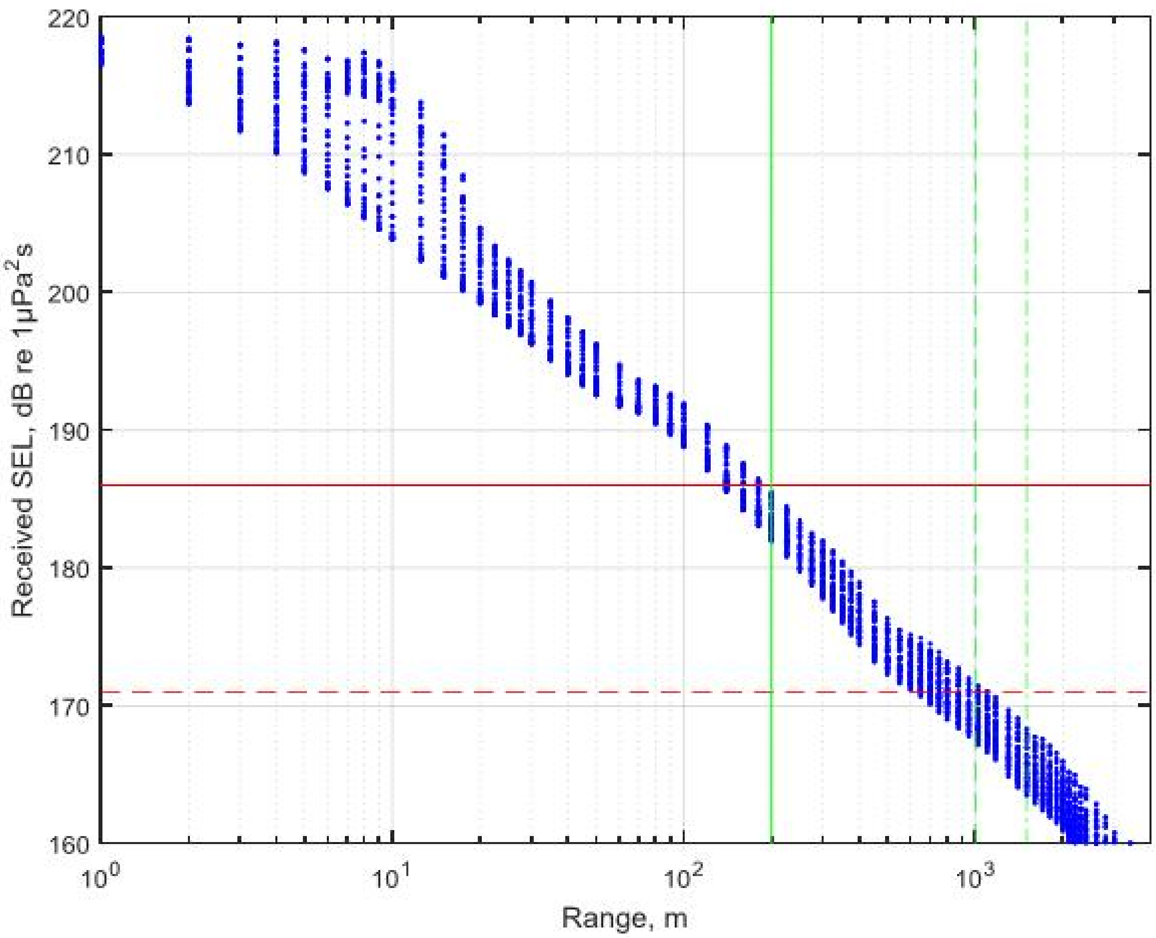
Figure 23 A Summary of Geo-Acoustic Regions of New Zealand



Short range modelling

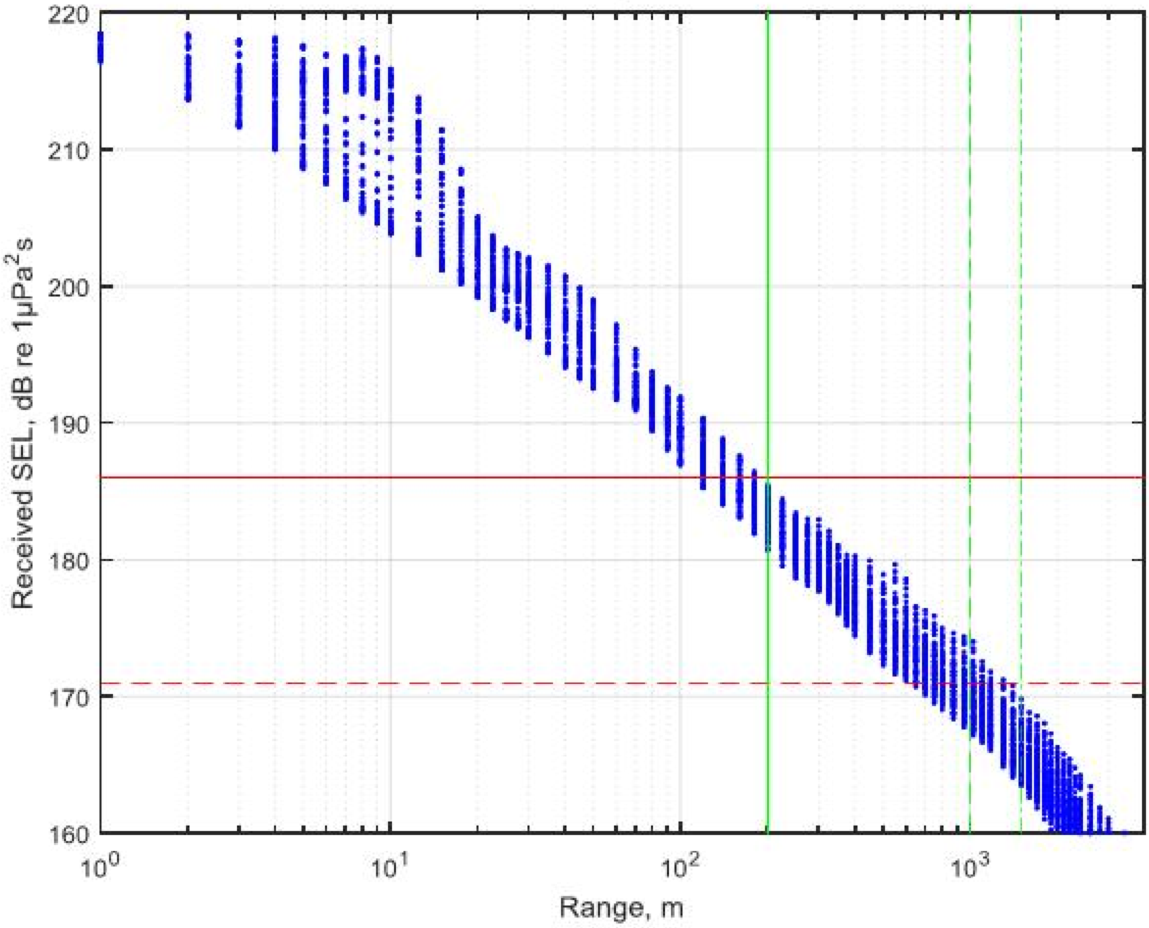
Short-range modelling predicts the received SELs over a range of a few kilometres from the source location, in order to assess whether the proposed survey complies with the regulatory mitigation zone SEL requirements as defined in the Code of Conduct. The short-range modelling results are depicted in **Figure 24** and **Figure 25** for S1 and S2 respectively; and are summarised in **Table 30**. These results demonstrate that the maximum received SELs 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 two selected source locations. However, at both of the selected modelling locations, maximum received SELs are slightly above 171 dB re 1µPa^2·s at 1.0 km from the source indicating that the 1 km mitigation zone does not sufficiently protect marine mammals from behavioural disturbance. On the basis of these results Schlumberger will solely use the larger 1.5 km mitigation zone throughout the Western Platform Multi-Client 3D Seismic Survey for all Species of Concern, regardless if they are accompanied by calves or not. This approach affords greater protection to Species of Concern from behavioural disturbance.

Figure 24 Maximum Received SELs from the Acoustic Source at Location S1



Red lines show mitigation thresholds of 186 dB re 1µPa^2·S (solid) and 171 dB re 1µPa^2·S (dash). Green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Figure 25 Maximum Received SELs from the Acoustic Source at Location S2



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).

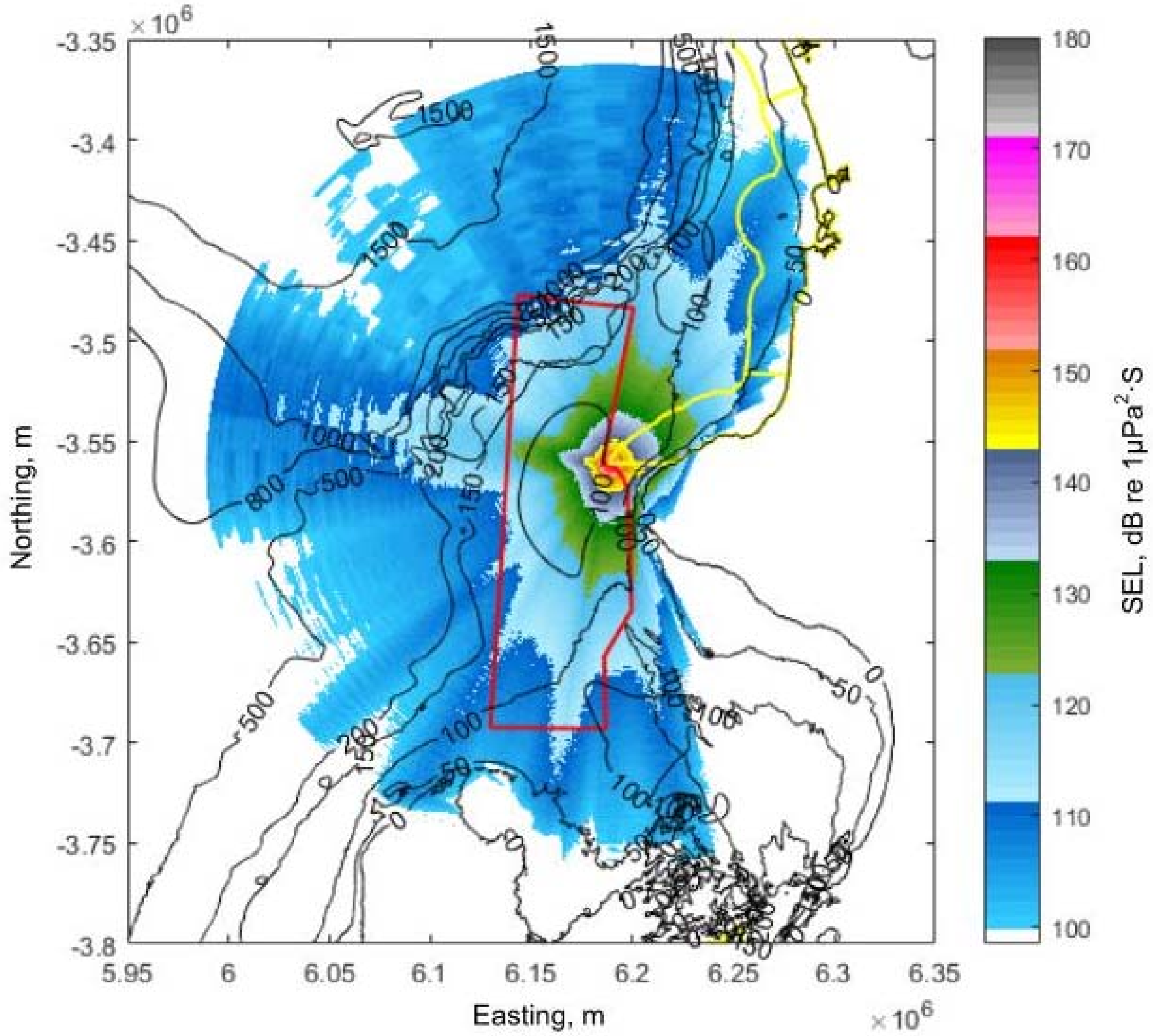
Table 30 Predicted Maximum SELs at the Standard Code of Conduct Mitigation Zones

Source location	Water depth, m	Seafloor	SEL at different ranges, dB re 1µPa²·s		
			200 m	1.0 km	1.5 km
S1	80	Fine sand	185.5	171.6	168.3
S2	30	Fine sand	184.8	174.2	169.8

Long range modelling

Long-range modelling predicts the received SELs over a range of tens to hundreds of kilometres from the source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas. The long-range modelling results are illustrated in **Figure 26** and indicate that 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 26 Modelled Maximum SELs to a Range of 200 km

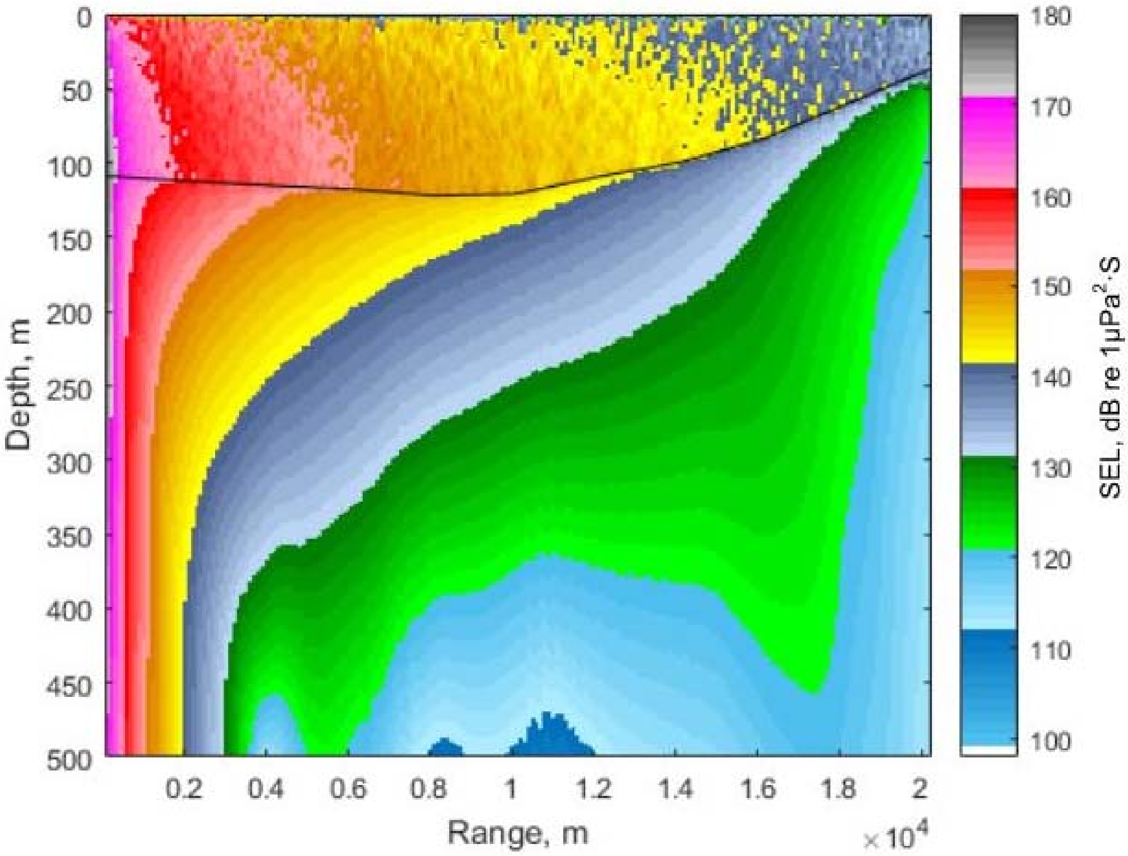


High noise attenuation is predicted for the propagation paths with up-slope bathymetry profiles (i.e. within the shallow water region in the eastern direction), as a result of the stronger interaction between the sound signal and seabed. In addition, the down-slope bathymetry profiles within the continental slope section and beyond favour the sound propagation in the northern direction. The maximum SELs received from the source location L1 in the western direction at a distance of 200 km are predicted to be as high as 110 dB re 1μPa²·s.

The nearest boundary of the West Coast North Island Marine Mammal Sanctuary is approximately 1.0 km from the source location L1. The maximum SELs received at the nearest boundary point are predicted to be up to170 dB re 1μPa²·s.

The long-range modelling is also able to provide an estimate of the SELs at the seafloor, where even directly below the acoustic source, SELs no greater than 180 dB re 1μPa^2·s are predicted (**Figure 27**).

Figure 27 Modelled SELs with Range and Water Depth in the Crossline Direction



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

6.2.2.2 Potential physiological effects

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). The Code of Conduct outlines threshold levels aimed at protecting marine mammals from physiological effects; however, such impacts are not limited to marine mammals, and the sections below also discuss the potential for trauma or damage to other faunal groups that may also be at risk.

6.2.2.2.1 Marine mammals

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

The main type of auditory damage documented in marine mammals is a 'threshold shift'. A threshold shift occurs when the exposed individual exhibits an elevation in the lower limit of their auditory sensitivity, in other words they suffer from hearing loss. Threshold shifts can be permanent or temporary, although temporary threshold shifts are more common in marine mammals as their mobile, free-ranging nature means they are usually able to avoid areas in which SELs would be dangerously high. It is believed that to cause immediate serious permanent physiological damage to marine mammals, SELs need to be very high (Richardson et al., 1995). Although different SELs affect marine mammal species in different ways, permanent threshold shifts (i.e. permanent hearing loss) are thought to occur between 218 – 230 dB re 1 μPa^2-s (Southall et al., 2007).

Following Southall et al. (2007), the Code of Conduct sets thresholds that predict the physiological effects on marine mammals in New Zealand waters during seismic surveys. This 'injury criteria', is exceeded if marine mammals are subject to SELs greater than 186 dB re 1μPa2.s (DOC, 2013). The Code of Conduct requires mitigation measures that are specifically designed to minimise the potential for marine mammals to be subject to SELs that could cause temporary or permanent threshold shifts. Compliance with these mitigation measures is the fundamental way in which Schlumberger intends to mitigate against auditory damage for marine mammals during the Western Platform Multi-Client 3D Seismic Survey.

STLM results for the Western Platform Multi-Client 3D Seismic Survey indicated that compliance with the 186 dB re 1μPa^2.s threshold occurs at a maximum distance of 190 m; hence compliance with the standard Code of Conduct mitigation zone of 200 m for 'other marine mammals' will sufficiently protect these marine mammals from physiological effects. As per the Code of Conduct requirements, Schlumberger will conduct ground-truthing during the survey to verify the results of the STLM. In order to do this, representative data recorded on the seismic streamers during the seismic survey will be used to compare actual water column sound exposure levels with STLM predictions.

If exceedances of the physiological threshold for individual marine mammals do occur during the Western Platform Multi-Client 3D Seismic Survey, temporary threshold shifts may result. However, permanent threshold shifts are unlikely due to the typical avoidance behaviour exhibited by marine mammals and compliance with the Code of Conduct (i.e. pre-start observations, soft start and shut-down procedures) which serves to minimise the risk to marine mammals to as low as reasonably practicable.

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

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

6.2.2.2.2 Seabirds

As high intensity acoustic disturbances have the potential to cause physiological harm to other taxa (e.g. marine mammals, fish, etc.), it is reasonable to assume that seabirds could also suffer physiological damage 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 in the vicinity of the vessel 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 targeted by a number of seabird species are likely to be displaced from the immediate vicinity of the acoustic source. Seabirds are expected to detect this change in fish distribution and cease any foraging.

On account of the above, it is considered that the risk of physiological effects to seabirds during the Western Platform Multi-Client 3D Seismic Survey is ***low*** (minor × unlikely).

6.2.2.2.3 Marine Reptiles

Little information exists as to the potential effects of seismic operations 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 investigated hearing loss or damage to sensory hairs from underwater noise, (Popper et al., 2014). As a result, there is no information available on the noise levels required to elicit a threshold shift in marine turtles. Resilience of fresh turtle cadavers to explosives was concluded by Ketten et al (2005) and cited by Popper et al (2014) as evidence that they may also 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.

Sea turtles are unlikely to be present during the Western Platform Multi-Client 3D Seismic Survey, therefore the risk of physiological effects from underwater noise is considered to be ***low*** (minor × unlikely).

6.2.2.2.4 Fish

Sound affects fish physiology in a number of ways depending on the source level and species affected. Effects include increased 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 sensory organs (McCauley et al., 2003).

Scholik and Yan (2002) reported that a hearing threshold shift in fathead minnows was directly correlated to the sound frequency and duration of exposure. A temporary threshold shift was observed after one hour of exposure to white noise at >1 kHz; however, no threshold shift occurred at 0.8 kHz. Seismic surveys typically use an acoustic source that operates at a significantly lower frequency (2 - 250 Hz) than that used to demonstrate an effect in this study.

Varying degrees of threshold shifts in northern pike, broad whitefish and lake-chub were observed when fish were exposed to a 730 in^3 acoustic source (Popper et al., 2005). Although the degree of threshold shift varied, recovery of all species occurred within 24 hours of exposure.

McCauley et al. (2003) looked at the effects of seismic source exposure on snapper (*Pargrus auratus*); 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. Fish were sacrificed after the experiment 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.

In conjunction with physiological effects, it's important to note that fish will typically move away from a loud acoustic source (see **Section 6.2.2.4.2**), therefore minimising their exposure and the potential for any hearing damage. Hence, these data can be interpreted as a 'worst case scenario' for fish that remain in close proximity to the seismic source. Additionally, even in close proximity to the source, not all species will be affected equally. For example, in the Popper *et al.,* (2005) study, two of the species experienced a temporary threshold shift while the third showed no evidence of an impact.

A comprehensive investigation was conducted to assess the effects of a seismic survey on reef fish in Western Australia (Woodside, 2007). Water depths during this study ranged from 20 – 1,100 m and the study used a seismic source with a total capacity of 2,005 in^3. This study assessed fish diversity and abundance, coral health, and pathology changes in sensitive auditory tissues. Sound loggers and remote underwater video was deployed and fish exposure cages were utilised to contain captive reef fish. The two key findings of this study were: 1) no temporary or permanent threshold shifts were detected in any species, and 2) no long-term impacts on fish populations were identified.

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 31**.

Table 31 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}

During the Western Platform Multi-Client 3D Seismic Survey there is potential for the acoustic source to induce temporary physiological effects on fish species that are present in close proximity to the acoustic source; however, the risk of any lasting physiological effects are considered to be ***low*** (minor × unlikely) as most pelagic fish are predicted to avoid the greatest SELs.

6.2.2.2.5 Cephalopods

Acoustic trauma has been observed in captive cephalopods. Andre et al. (2011) exposed four species to low frequency sounds with SELs of 157 ± 5 dB re 1 μPa (peak levels at 175 re 1 μPa). All exposed animals exhibited changes to the sensory hair cells (statocysts) responsible for balance, with damage becoming more pronounced in animals continuously exposed for up to 96 hours. This study estimated that trauma effects could occur out to 1.5 - 2 km from an operating acoustic source. No data is available for octopuses; however they too rely on statocysts for balance and positioning information; hence it is possible that they could also suffer from some auditory damage from underwater noise.

Given their pelagic lifestyle, there is the potential for squid to come in close proximity to the acoustic source during the Western Platform Multi-Client 3D Seismic Survey. However, the duration of exposure is expected to be low as squid can readily move away from the highest SELs. In addition, squid are generally short-lived, fast growing species with high fecundity rates (MPI, 2015); life history traits that mean they are well adapted to disturbance. As a result, there is no anticipated long-term risk to squid populations.

As reef dwelling species, octopuses in the Operational Area will primarily be associated with coastal waters which will largely be avoided by the Western Platform Multi-Client 3D Seismic Survey.

Based on the information above the risk of physiological trauma to cephalopod species is considered to be ***low*** (negligible × occasional).

6.2.2.2.6 Benthic Invertebrates

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).

In waters deeper than about 15 m, 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 Western Platform Multi-Client 3D 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 (**Figure 27**).

Published literature on crustaceans, shellfish and deepwater benthic invertebrates (i.e. corals) are provided below.

Overall, the risk of the Western Platform Multi-Client 3D Seismic Survey on benthic invertebrates is considered to be ***low*** (negligible × possible), with any effects predicted to be highly localised and no population effects anticipated.

<u>*Crustaceans*</u>

Studies in the 1990s indicted that crustaceans were relatively tolerant to acoustic disturbance, with little crustacean mortality observed below sound levels of 220 dB re 1µPa@1m (Royal Society of Canada, 2004), with this resilience to sound exposure attributed to the lack of a swim bladder (Moriyasu et al., 2004). Moriyasu et al (2004) compiled a literature review of some of these early studies, which are summarised 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 (Kosheleva, 1992; Dalen, 1994 as reported in Moriyasu et al., 2004) with no physiological effects detected; and
- 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).

The presiding theory of relative resilience for crustaceans has been challenged by recent physiological studies. Day et al. (2016) exposed red rock lobster (*Jasus edwardsii*; also found in New Zealand) to a 150 in^3 in field studies off Tasmania. Key findings from this study were:

- Statocyst hair cells 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
- 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.

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).

<u>*Shellfish*</u>

Variable effects of underwater noise have been reported for shellfish, with findings ranging from zero impacts to shell damage and blood chemistry changes. Examples of effects of seismic surveys on shellfish include:

- Blue mussels (*Mytilus edulis*) exposed to a seismic source with a source level of 223 dB re 1µPa at distances of 0.5 m or greater (Kosheleva, 1992; Dalen, 1994 as reported in Moriyasu et al., 2004) showed no physiological effects;
- 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 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.

The potential for physiological damage of shellfish varies with the species exposed and the exposure circumstances (e.g. source level and duration, etc.). Based on previous literature, little shellfish mortality is expected below sound levels of 220 dB re 1µPa@1m (Royal Society of Canada, 2004).

Deepwater Benthic Communities

The potential effects of sound on deepwater benthic communities are not well understood and there is a notable lack of literature on the topic. Potential effects on threatened species such as deepwater corals are of primary concern. See **Section 6.2.2.2.7** for potential effects of seismic surveys on coral larvae.

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

The information above provides evidence to suggest that deepwater coral communities could be relatively tolerant of seismic surveys. Deepwater coral communities are not prevalent within the Operational Area.

6.2.2.2.7 Plankton

Larvae of fish and invertebrates generally have a pelagic planktonic stage during early development. Plankton, when in close proximity to an operating acoustic source is vulnerable to physiological damage. Until recently it was believed that mortality of plankton would only occur within 5 m of an active acoustic source (Payne, 2004); however, new research by McCauley et al. (2017) has provided evidence to suggest seismic surveys may cause significant mortality to zooplankton populations.

The health of the plankton community in relation to exposure to a single 150 in^3 acoustic source was assessed by McCauley et al. (2017) using sonar surveys, net tows for zooplankton abundance, and counts of dead zooplankton both before and after seismic exposure. Community composition included copepods (71%), cladocerans/water fleas (15%), euphausiid/krill larvae (*Nyctiphanes australis*) (4%), appendicularians (5%), and ‘other’ (5%). Key findings presented by McCauley et al. (2017) were:

- 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 µPa^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 μPa^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 Australian Petroleum Production & Exploration Association (APPEA) has commissioned CSIRO to model the potential local and regional impacts of a typical marine seismic survey in the North West of Australia based on the McCauley et al. (2017) results. APPEA is the national body representing Australia’s oil and gas exploration and production industry, of which Schlumberger are a member of.

Early results from the CSIRO modelling 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 zooplankton populations recovered 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 Western Platform Multi-Client 3D Seismic Survey which is proposing to use a 5,085 in^3 acoustic source over a Survey Area which covers approximately 6.300 km^2 for a period of three months. In comparison, the Richardson et al. (2017) survey modelled a 3,200 in^3 acoustic source over an an area of 2,900 km^2 for 35 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 Western Platform Multi-Client 3D Seismic 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),

Further research is being planned to assess potential impacts of seismic survey sound on plankton communities which will be part of a three-year study through the Australian Institute of Marine Science to enhance the understanding of how seismic sound affects the marine environment.

Potential effects to commercially important larvae and threatened species are of greatest concern. New Zealand scallop larvae were experimentally exposed to seismic pulses (160 dB re 1 μPa at 1m at 3 second intervals) in order to assess the effect of noise on early larval development (Aguilar de Soto et al., 2013). Within one hour of fertilisation scallop larvae were suspended at a depth of 1 m within a tank containing seawater. 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. This study provided the first evidence that continual sound exposure causes growth abnormalities in larvae and it is assumed that other larval shellfish and fish may be prone to similar impacts.

Despite indicating larval vulnerability, it is important to put the results of the Aguilar de Soto et al. (2013) study into context. The experimental study was restricted to newly fertilised larvae that were exposed to high intensity sounds every 3 seconds for an extended duration (24 - 90 hours). In contrast, the Western Platform Multi-Client 3D Seismic Survey will have a shot-point interval of 10.8 seconds and exposure time will be much shorter since the source is constantly moving and will pass most acquisition lines only once. Furthermore, this study used pulse duration of 1.5 seconds whereas the pulse duration for a seismic array is typically around 30 milliseconds.

With regard to threatened species, larval mortality of deepwater coral species should be considered as a consequence of seismic surveys. In New Zealand, deepwater corals (e.g. black coral) are generally found at depths of 200 m or more (see **Section 5.2.7**). Mortality of pelagic coral larvae is possible; however, black coral larvae are negatively buoyant and do not disperse very far (Parker et al., 1997; Consalvey et al., 2006); therefore should any coral larvae be present in the Operational Area, the depth at which it occurs is likely to offer some protection from dangerous SELs. In addition to this, the likelihood of black or stylasterid coral in the Operational Area is low (see **Section 5.2.7**).

Stakeholders have in the past voiced concern about the impacts of seismic operations on larval settlement. While this issue hasn't been raised in regards to the Western Platform Multi-Client 3D Seismic Survey, the impacts on rock lobster settlement have been discussed in the past. Day et al. (2016) assessed the development and hatching rates of red rock lobster larvae following seismic exposure and could not detect any effects between exposed larvae and control larvae. The effects of seismic surveys on rock lobster settlement rates in New Zealand are unknown; however, the primary settlement phases typically occur in late winter/spring (Forman et al., 2014), prior to the survey commencing.

It is noted that impacts on zooplankton popultaions may lead to indirect effects on other components of the marine food web, these effects are discussed in **Section 6.2.2.5.**

As indicated from the studies above, seismic operations may have some detrimental effects on plankton communities. The survey design of the Western Platform Multi-Client 3D Seismic Survey will contribute towards minimising these effects as the survey lines, which run north-south, are very long, with each line taking approximately 24 hours to complete. This means that the survey vessel will not be passing through the same part of the Operational Area continuously. This coupled with the high energy offshore marine environment of the Operational Area (which will help promote fast recovery of plankton populations on account of dispersal and mixing) suggests that the population level risk to plankton will be ***medium*** (minor × likely).

6.2.2.3 Potential behavioural effects

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 preferred habitat. On this basis avoidance and displacement are the primary behavioural effects expected from the Western Platform Multi-Client 3D Seismic Survey.

Displacement from an area can lead to relocation into sub-optimal or high-risk habitats, resulting in negative consequences such as increased exposure to predators, decreased foraging or mating opportunities, alterations to migration routes etc. Displacement could also have indirect effects, for instance feeding activities of predators could be disrupted by the displacement of prey species which could lead to energetic consequences.

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

6.2.2.3.1 Marine mammals

Avoidance of seismic operations has been widely documented for marine mammals (e.g. Goold, 1996; Stone & Tasker, 2006; Thompson et al., 2013). In a large scale review of 201 seismic surveys conducted in UK waters, researchers found that most odontocetes were more likely to exhibit a clear lateral avoidance response, killer whales and mysticetes; however, generally demonstrated a more moderated lateral response, while sperm whales showed no discernible response.

Harbour porpoises exposed to a 470 in^3 acoustic source array over ranges of 5 – 10 km, at received peak-to-peak sound pressure levels of 165-175 dB re 1 µPa and sound exposure levels of 145 – 151 dB re 1µPas-1 were temporarily displaced (Thompson et al., 2013). However, the animals were typically detected again at affected sites a few hours after the exposure. Moreover, the level of response declined throughout the 10 day survey period (Thompson et al., 2013). Thompson et al. (2013) concluded that prolonged seismic surveys did not lead to broad-scale displacement of marine mammals and that impact assessments should focus on sub-lethal effects. Note however that the acoustic source used for this study was far smaller than the source proposed by Schlumberger; hence the zone of influence around the larger source is expected to be larger.

The effects of a seismic survey on the migratory behaviour of bowhead whales were documented by Richardson et al. (1995). Evidence was found for a 20 – 30 km avoidance zone around the associated seismic vessel. 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., 2003a). In open seas it is unlikely that temporary displacement would have significant energetic consequences for migrating whales, but displacement could have more significant consequences in confined waterways.

In some instances, marine mammals have been recorded swimming rapidly away from an acoustic source with noticeable surface behaviours such as breaching (McCauley et al., 1998; McCauley et al., 2003a). An increase in surface behaviour has been interpreted as a way of reducing exposure to the higher sounds levels from the acoustic source on account of the ‘Lloyd mirror effect’ (Carey, 2009) which significantly reduces sound intensity in the upper-most part of the water column.

In addition to avoidance responses, there is also anecdotal evidence of marine mammals being attracted to seismic operations. For example, common dolphins have been observed repeatedly approaching an operating seismic vessel to bow ride as it entered shallow waters off the Taranaki coast. New Zealand fur seals are also known to approach operating seismic vessels from time to time (Lalas & McConnell, 2015).

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 include an increase in energy expenditure during foraging bouts in order to detect and capture prey, or a decrease in foraging success as a prey source, in responding to seismic survey noise, may no longer be available to marine mammals.

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).

The behavioural impacts of seismic surveys on beaked whales are largely unknown, but based on their observed responses to mid-frequency active sonar (increased swim speed, unusual dive behaviours and multiple unusual mass strandings that have ultimately caused the death of individuals) this group is believed to be particularly sensitive to anthropogenic noise (Stimpert et al., 2014). In addition to behavioural responses, physiological responses have also been reported for cetaceans exposed to mid-frequency active sonar; these include gas embolisms and changes in blood biochemistry (Fahlman 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.

With regards to the potential behavioural impacts on marine mammals during the Western Platform Multi-Client 3D Seismic Survey, the following considerations should be noted:

- Any avoidance or displacement will be temporary and will cease as soon as the survey is completed.
- 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 key concern. See **Section 6.2.2.5** for discussions about how changes in prey distribution may cause indirect effects on foraging cetaceans.
- Pygmy blue whales have been recorded in the South Taranaki Bight during all months of the year, and mother/calf pairs have been documented during summer (Torres & Klinck, 2016). Any displacement of this species during summer may therefore result in effects on nursery behaviours.
- With regard to impacts on migratory behaviour, 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 E**;
- A detailed Marine Mammal Mitigation Plan has been developed to guide operational requirements for the Western Platform Multi-Client 3D Seismic Survey (**Appendix D**);
- 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 behavioural disturbance to marine mammals; and
- Source modelling has been undertaken to ensure that the lowest possible 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 a ***medium*** (moderate × possible) risk to marine mammals during the Western Platform Multi-Client 3D Seismic Survey.

6.2.2.3.2 Seabirds

Although there is little information about the behavioural effects of seismic on seabirds, a number of authors have raised the possibility of disruption to feeding activities. For instance, Goudie and Ankney (1986) suggested that seabird feeding behaviours could possibly be interrupted by acoustic disturbance from the seismic vessel passing through feeding grounds; and MacDuff-Duncan and Davies, (1995) postulated that birds in the area could be alarmed as the seismic operations pass close-by, causing them to temporarily stop diving. In addition to the potential direct displacement of seabirds, the displacement of bait fish could lead to a reduction in the diving activities and foraging potential for seabirds in the immediate vicinity of the seismic operations.

Lacroix et al. (2003) assessed 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, in order to compensate for this nutritionally costly moult process, they increase their foraging time during this period. The findings of this study indicated that 1) 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 for duck distribution than seismic activities; 2) Seismic activity did not significantly change the diving intensity of ducks; and 3) The data collected provided no evidence to suggest any displacement away from active seismic operations.

Despite the identification of potential impacts, any disturbance to seabirds during the Western Platform Multi-Client 3D Seismic Survey would be strictly temporary and localised in nature. For these reasons, the potential effects are considered to be ***low*** (negligible × possible).

6.2.2.3.3 Marine Reptiles

It is unlikely that any marine reptiles will be present within the Operational Area during the Western Platform Multi-Client 3D Seismic Survey (**Section 5.2.4**). While no information is available on the effects of seismic surveys on sea snakes (although a study is underway by the University of Adelaide), patterns of avoidance and behavioural responses have been observed in sea turtles. 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.

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 ***low*** (minor × unlikely).

6.2.2.3.4 Fish and Fisheries

Investigations into behavioural impacts from seismic surveys on fish are typically either: 1) experiments during which caged fish are exposed to an acoustic source, or 2) studies which assess catch-effort data before and after a seismic survey. Caution must be exercised when interpreting both as variability in the experimental design (source level, line spacing, timeframe, geographic area etc.) and the subjects (species, wild or farmed, demersal or pelagic, migrant or site-attached, age etc.) often make it difficult to draw overall conclusions and comparisons. Furthermore, captive studies typically only provide information on the behavioural responses of fish during and immediately after the onset of noise (Popper & Hastings, 2009). Beyond this, all behavioural observations are potentially biased by the fact that the subjects are constrained and may be unable to exhibit avoidance behaviours which would be possible in the wild.

In preparing this MMIA, a number of behavioural studies were reviewed. In general, little indication of long-term behavioural disruption was apparent. Short-term responses were relatively common and included startle responses (Pearson et al., 1992; Wardle et al., 2001; Hassel et al., 2004; Boeger et al., 2006); modification in schooling patterns and swimming speeds (Pearson et al., 1992; McCauley et al., 2000; Fewtrell & McCauley, 2012); freezing (Sverdrup et al., 1994); and changes in vertical distribution in the water column (Pearson et al., 1992; Fewtrell & McCauley, 2012). Evidence of habituation was observed through a decrease in the degree of startle response (Hassel et al., 2004).

Short-term displacement includes either vertical or horizontal avoidance away from the acoustic source during seismic operations (Pearson et al., 1992; McCauley et al., 2000; Colman et al., 2008; Handegard et al., 2013). Pelagic fish tend to dive deeper (McCauley et al., 2000), while reef species will return to the reef for shelter as the seismic vessel approaches and resume normal activity once the vessel has passed (Woodside, 2007; Colman et al., 2008). 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.

Changes to fish behaviours as a result of seismic surveys can potentially affect commercial fishing operations (McCauley et al., 2000). A reduction in catch per unit effort in close proximity to seismic operations has been demonstrated in a number of cases (e.g. Skalski et al., 1992; Engas et al., 1996; Bendell, 2011; Handegard et al., 2013). These effects are typically only short term, lasting up to five days following the conclusion of seismic operations and there has been no evidence of long-term displacement. Gausland (2003) has debated reported reductions in catch per unit effort, attributing it instead to natural fluctuations in fish stocks or long-term negative trends.

Over the last 40 years seismic surveys have been conducted frequently in the North Sea and fishing grounds in the Norwegian and Barents Seas are often affected. 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 the survey area for distances up to 5 km from the active source, however, these reductions were temporary with catch rates returning to normal within 24 hours of the 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 Lyme Bay (UK), the distribution of bass was documented during a seismic survey using a peak source of 202 dB re 1µPa@1m over a period of three and a half months. No long term changes in distribution where observed and data from tagged fish demonstrated that there were no large scale emigrations from the survey area (Pickett et al., 1994). Another example from the Adriatic Sea, reported that no changes in pelagic biomass were observed following acoustic disturbance with a peak of 210 dB re 1µPa@1m; indicating that catch rates were unlikely to be affected (Labella et al., 1996). Further evidence of little or no effect comes from a large scale study on catch rates around the Faroe Islands. This study noted that although the majority of fishers perceived a decrease in catch during seismic operations, the analysis of logbook records during periods both with and without seismic operations revealed no statistically significant effect of seismic activity in the area (Jakupsstovu et al., 2001).

Based on the examples above, some short-term distributional changes for fish are possible during the Western Platform Multi-Client 3D 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.

Acoustic disturbance to fish during the Western Platform Multi-Client 3D Seismic Survey will be minimised by:

- The use of soft starts as prescribed by the Code of Conduct; and
- Operations will occur 24/7 (weather and marine mammal encounters permitting) to ensure the survey will progress as quickly as possible; hence the duration will be minimised.

Commercial fishers have been advised of the Western Platform Multi-Client 3D Seismic Survey, they will be advised of the predicted start date closer to commencement and will be provided with 48 hour look ahead reports for the vessels planned survey lines every 24 hours to minimise conflict.

With these mitigation measures in place it is considered that the risk of behavioural disruption to fish and the consequences to fisheries during the Western Platform Multi-Client 3D Seismic Survey is ***medium*** (minor × likely).

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.

Acoustic disturbance to cephalopods may occur during the Western Platform Multi-Client 3D Seismic Survey, but will be minimised by:

- The use of soft starts as prescribed by the Code of Conduct; and
- Operations will occur 24/7 (weather and marine mammal encounters permitting) to ensure the survey will progress as quickly as possible; hence the duration will be minimised.

With these mitigation measures in place it is considered that the risk of behavioural changes to cephalopods during the Western Platform Multi-Client 3D Seismic Survey is ***medium*** (minor × likely).

6.2.2.3.6 Benthic Invertebrates

Crustaceans

There is limited information about the behavioural response of crustaceans to acoustic disturbance; however a summary of the available literature on this topic is provided below.

Catch rates of three species of shrimp (southern white shrimp, southern brown shrimp and Atlantic seabob) were unchanged during a seismic survey (peak source level 196 dB re 1 µPa at 1 m), indicating no detectable effects on these species (Andriguetto-Filho et al., 2005). Similarly, Parry and Gason (2006) documented no effect on catch rates from a lobster fishery spanning 25 years during which multiple seismic surveys occurred (28 2D and five 3D). In this study, the number of seismic pulses was correlated to catch per unit effort data over 12 depth stratified regions (0-50 m, 51-100 m, 101-150 m) in the Western Rock Lobster Zone (Western Victoria, Australia). Catch per unit effort data detected no significant change in catch rates during the weeks and years following seismic surveys leading authors to conclude a lack of apparent impact on rock lobster fisheries.

A field experiment was recently 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).

The most well-known and commonly harvested crustacean species in New Zealand is the red rock lobster, commonly known as crayfish. They are an important species from a commercial, cultural and recreational perspective. Red rock lobster is found in coastal waters where rocky subtidal reefs are present. Commercial fishing for red rock lobster only occurs within the 12 Nm. As the Western Platform Multi-Client 3D Seismic Survey will be largely acquired outside of the CMA, the effects on red rock lobster fisheries will be limited. However, rock lobster around Cape Egmont may be subject to higher SELs on account of the seismic vessel coming closer to shore here.

Scampi and deepwater crabs (red crab, giant spider crab and two species of king crab) are also commercially harvested in N*ew* Z*ealand*. Scampi are targeted by trawlers on grounds to the east of the North Island, the Chatham Rise, and the Auckland Islands, while deepwater crab species are targeted by pot deployed in water depths up to 1,500 m (MPI, 2015). No overlap is predicted between these fisheries and the Western Platform Multi-Client 3D Seismic Survey.

Based on the information above, the potential effect of acoustic disturbance on crustaceans and crustacean fisheries is considered to be ***low*** (minor × unlikely).

Shellfish

There is a real paucity of information with regards to the behavioural effects of seismic surveys on shellfish. The behavioural response of scallops to seismic exposure was assessed by Day et al. (2016) who found that seismic exposure increased the rate that scallops buried themselves into the sediment, but that exposed scallops were slower at righting themselves than control scallops. The ecological implications of these results require further study and the authors suggest that the slowed righting response could lead to higher rates of predation for exposed scallops.

Shellfish distribution is typically limited to sheltered, shallow, coastal waters where some hard substrate is available for larvae to settle onto. Harvestable coastal shellfish beds are of subsequent social and cultural significance. The predominantly offshore nature of the Operational Area suggests that shellfish will not suffer significant behavioural effects during the Western Platform Multi-Client 3D Seismic Survey; hence the potential population level effects of acoustic disturbance on shellfish behaviour is considered to be ***low*** (minor × unlikely).

6.2.2.4 Potential Perceptual Effects

6.2.2.4.1 Marine Mammals

Marine mammals use sound to inform a range of behaviours; foraging, navigation, communication, reproduction, parental care, avoidance of predators, and to gain overall awareness of the environment (Thomas et al., 1992; Johnson et al., 2009). The ability to perceive biologically important sounds is therefore crucial to these animals. Anthropogenic sounds in the same frequency as biological signals can interfere with biologically important sounds and potentially lead to significant individual effects (Richardson et al., 1995; Di Iorio and Clark, 2009). This interference is referred to as ‘auditory masking’.

Cetaceans are broadly separated into three categories (Southall et al., 2007):

- Low frequency cetaceans that have an auditory bandwidth of 0.007 kHz and 22 kHz. Species from this group that could occur in the Operational Area include southern right whale, minke whale, sei whale, humpback whale, blue whale, and fin whale.
- Mid-frequency cetaceans with an auditory bandwidth of 0.15 kHz and 160 kHz. Species from this group that 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 which an auditory bandwidth of 0.2 kHz and 180 kHz. Species from this group that could occur in the Operational Area include the Hector’s and Maui’s dolphin, and pygmy sperm whales.

The sound frequencies that are emitted by seismic acoustic sources are broadband, with most of the energy concentrated between 0.1 kHz and 0.25 kHz. The greatest potential for interference with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum (**Table 32**); i.e. the lowest frequency cetaceans are particularly affected since they have the most overlap with the frequencies of the seismic survey acoustic sources (**Figure 28**). Auditory masking of mid and high frequency cetacean vocalisations are less likely as these species generally operate at higher frequencies than those generated by a seismic survey.

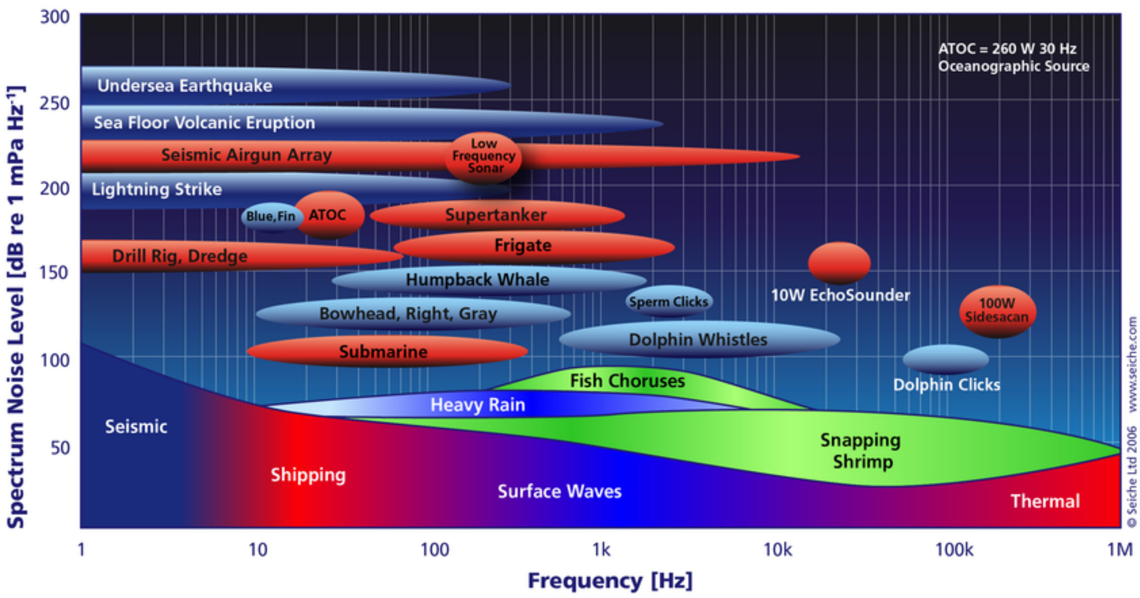
Table 32 Cetacean Communication and Echolocation Frequencies

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

Figure 28 Ambient and Localized Noise Sources in the Ocean



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

A number of studies have documented adaptive responses to anthropogenic underwater noise. Responses include changes in vocalisation strength, frequency, and timing (McCauley et al., 1998; Lesage et al., 1999; McCauley et al., 2003a; Nowacek et al., 2007; Di Iorio & Clark, 2009; Parks et al., 2011; van Ginkel et al., 2017). For instance, blue whales will increase their calls (emitted during social encounters and feeding) when a seismic survey is operational in the area (Di Iorio & Clark, 2009). These adaptations are thought to increase the probability that communication signals will be successfully received by conspecifics by reducing the effects of auditory masking.

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.

Based on the information presented above, it is likely that whales in the vicinity of the Operational Area will be subject to some masking. As a result, the risk of marine mammals suffering perceptual effects is considered to be ***high*** (moderate × likely). This is particularly so for blue whales, whereby a large portion of (presumed) blue whale feeding habitat will be exposed to perceptual sound for the majority of the summer months. The survey design of the Western Platform Multi-Client 3D Seismic Survey will contribute towards minimising the effects of masking by the use of very long, north-south oriented survey lines; whereby each line will take approximately 24 hours to complete. This means that the survey vessel will not be passing through the same part of the Operational Area continuously and whales at the southern end of the Operational Area will have periods of time when the seismic vessel is distant and vocalisations will be more readily heard and received between conspecifics.

6.2.2.4.2 Fish

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

Radford et al. (2014) 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 Western Platform Multi-Client 3D Seismic Survey may lead to masking for some fish species.

As masking of fish communication by anthropogenic sound has been demonstrated, the risk of masking of fish from the Western Platform Multi-Client 3D Seismic Survey is considered to be ***medium*** (minor × possible).

6.2.2.5 Potential Indirect Effects

As well as the previously discussed direct physiological, behavioural and perceptual effects on marine mammals from underwater noise, there is also the potential for marine mammals to suffer from indirect effects of noise exposure. These 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). Although the possibility of indirect effects is undeniable, it is important to note that as described in the previous sections, the effects of noise on marine mammals varies with species, individuals, age, sex, past exposure and behavioural state (IWC, 2007). Therefore indirect effects may or may not be detrimental depending on the specific circumstances of exposure. Regardless of their effect, it is clear however, that indirect effects are much more difficult to detect and measure.

Perhaps the most significant and immediate potential indirect effect of noise on marine mammals relates to changes in prey distribution and abundance. From the information presented in **Sections 6.2.2.2.7** and **6.2.2.3.4** we know that both the distribution and abundance of zooplankton and fish can change as a result of underwater noise. When such effects occur they can in turn lead to decreased foraging efficiency of marine predators such as marine mammals which can potentially compromise growth, body condition, reproduction and ultimately survival (Marine Mammal Commission, 2007).

With regard to the Western Platform Multi-Client 3D Seismic Survey, particular consideration must be given to the potential indirect effects that changes in krill distribution and abundance could have on pygmy blue whales in the South Taranaki Bight. **Section 5.2.1.1.1** provides evidence to suggest that foraging aggregations of blue whales are likely to be present in the Operational Area and that these individuals target krill (*Nyctiphanes australis)* as their primary prey (Torres et al., 2015). McCauley et al. (2017) has recently provided evidence to suggest seismic surveys may cause significant mortality of krill larvae. Not surprisingly, the distribution of pygmy blue whales in the South Taranaki Bight is closely linked to that of krill (Torres et al., 2015), where krill distribution in turn is linked to patches of cold nutrient rich surface water that vary both within and between years (Torres & Klinck, 2016). No information is available with regard to how adult krill are affected by seismic surveys, but the mortality of krill larvae as described by McCauley et al. (2017) suggest that seismic surveys may alter the distribution and abundance of krill in the vicinity of seismic operations. It is therefore possible that Western Platform Multi-Client 3D Seismic Survey could affect the prey availability of blue whales in the Operational Area.

In response to the McCauley et al. (2017) study, 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 Western Platform Multi-Client 3D Seismic Survey and that any individuals present (including mother and calf pairs) could be subject to energetic costs associated with reduced foraging efficiency.

Changes in prey distribution and abundance during the Western Platform Multi-Client 3D Seismic Survey are not strictly limited to krill, 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) (see **6.2.2.3.4**). Therefore it is possible that indirect effects could also affect predatory fish species and piscivorous marine mammals.

While the discussion above clearly identifies some potential for indirect effects on marine mammals and fish from the Western Platform Multi-Client 3D Seismic Survey, there is a general lack of scientific information about such effects. On account of this it is difficult to predict with any certainty what indirect effects might occur in the Operational Area and likewise it is challenging to propose any targeted management measures to avoid, remedy or mitigate indirect effects. It is possible however that the following management measures may serve to reduce the risk of indirect effects during the Western Platform Multi-Client 3D Seismic Survey:

- The limited duration of operational activities serves to reduce the temporal scale of indirect effects to an anticipated three months; and

- Long acquisition lines (north-south orientation) reduce the likelihood of the vessel passing through the same piece of water multiple times in a short period of time, and as result plankton abundance may be better able to recover from any mortality from seismic operations.

Based on the information provided above, the risk of indirect effects from the Western Platform Multi-Client 3D Seismic Survey is considered to be ***medium*** (minor × likely).

6.2.3 Waste discharges and emissions

Various types of waste will be produced (e.g. sewage, galley waste, garbage and oily water) by the survey vessels during the Western Platform Multi-Client 3D Seismic Survey. Inappropriate discharges of these wastes have the potential for adverse effects on the marine environment. The volume of waste generated is dependent on the number of crew on-board and the duration of the survey. All wastes produced will be controlled in accordance to Schlumberger's standard environmental practices, MARPOL requirements (as enacted by the Marine Protection Rules for operations in the EEZ) and the Resource Management (Marine Pollution) Regulations 1998 (for operations inside the CMA).

6.2.3.1 Potential effects from biodegradable waste

Sewage, greywater, galley waste and oily water represent the primary forms of biodegradable waste that could be produced during the Western Platform Multi-Client 3D Seismic Survey. Biodegradable waste at sea is decomposed by bacteria either in the water column or on the seabed. This decomposition process increases the biochemical oxygen demand in the surrounding area which can potentially limit dissolved oxygen for other marine organisms (particularly in low flow areas where water circulates slowly). Biodegradable wastes also often lead to areas of artificial enrichment of phosphorus and nitrogen which can trigger excessive algal growth in extreme cases (Perić, 2016; Wilewska-Bien et al., 2016).

The vessels involved with the Western Platform Multi-Client 3D Seismic Survey have on-board sewage treatment plants which ensure a high level of treatment before any sewage or greywater is discharged. Where applicable, vessels involved in the Western Platform Multi-Client 3D Seismic Survey will be required to hold an International Sewage Pollution Prevention Certificate.

With regard to galley waste and in accordance with the New Zealand Marine Protection Rules, biodegradable food scraps will only be discharged to sea at distances greater than 12 Nm from land. Between 3 and 12 Nm from land only waste that has been comminuted to less than 25 mm will be discharged.

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

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

The risk from routine discharges of biodegradable waste during the Western Platform Multi-Client 3D Seismic Survey is considered to be ***low*** (negligible × possible).

6.2.3.2 Potential effects from non-biodegradable waste

Non-biodegradable solid waste in the marine environment can have severe detrimental effects on marine fauna. These 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 in the water column (Derraik, 2002). Plastics have been found in the gut contents of various species of seabird, fish, turtles and marine mammals (Derraik, 2002). These wastes persist in the marine environment for long periods of time, and may be transported large distances (Li et al., 2016).

All non-biodegradable wastes during the Western Platform Multi-Client 3D Seismic Survey will be returned to shore and will be disposed of in strict adherence to local waste management requirements with all chain of custody records retained. The environmental risk of any non-biodegradable discharges to the marine environment is considered to be ***low*** (negligible × rare).

6.2.3.3 Potential effects from atmospheric emissions

Combusted exhaust gasses represent the principle sources of potential atmospheric emissions during the Western Platform Multi-Client 3D Seismic Survey. Most of these gaseous emissions will be in the form of carbon dioxide and carbon monoxide; however, smaller quantities of other gasses such as nitric oxide, nitrogen dioxide and sulphur dioxide may be emitted (Steiner et al., 2016). Greenhouse gas emissions such as these are linked to climate change, and atmospheric emissions are also related to a reduction in ambient air quality; leading to human health issues in populated areas such as pulmonary disease, cardiovascular disease and cancer (Steiner et al., 2016).

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

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

6.2.4 Cumulative Effects

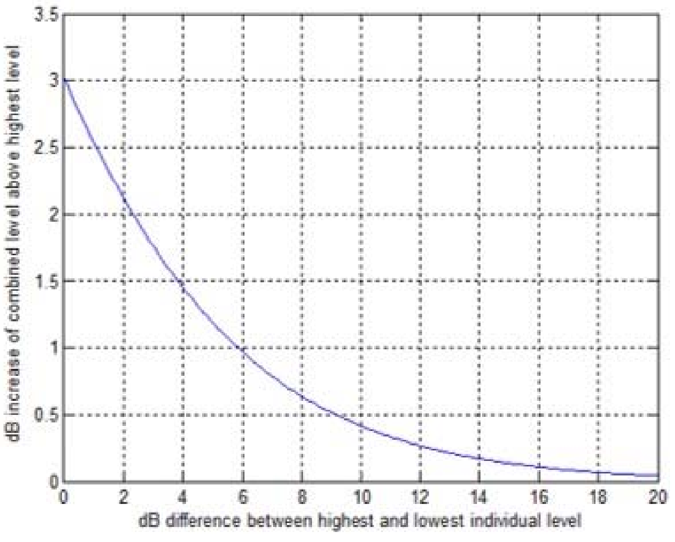
In this section 'cumulative effects' refers to the interaction of the potential effects from the Western Platform Multi-Client 3D Seismic Survey with environmental effects that arise from other marine activities (e.g. other seismic surveys, other marine traffic, fishing operations, etc.). Of primary concern for seismic surveys is the potential for cumulative acoustic effects that could result when multiple sources of underwater noise combine to significantly increase the underwater sound profile above its natural baseline level. In particular, cumulative effects associated with other seismic surveys and other shipping traffic are discussed below.

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

A number of studies have recently provided evidence to suggest that in the presence of consistent noise marine mammals do adapt their vocalisations, presumably to mitigate against the effects of auditory masking (e.g. McDonald et al., 2009; McGregor et al., 2013). These studies support the notion that the most significant masking effects can perhaps be expected in areas where baseline noise levels are typically low.

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 1μP^{2}s, 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 1μP^{2}s, and Survey B by itself would also produce an SEL of 160 dB re 1μP^{2}s, then the two surveys combined will produce an SEL at the same location of 163 dB re 1μP^{2}s (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 1μP^{2}s higher than Survey B, then the combined level is 1 dB re 1μP^{2}s higher than the higher of the individual SELs (i.e. Survey A) (**Figure 29**).

Figure 29 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.

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

Another seismic survey vessel will be operating in New Zealand waters throughout the duration of the Western Platform Multi-Client 3D Seismic Survey. This vessl (the *R/V Marcus Langseth*) will be operating from the Bay of Plenty to Cape Palliser through November/December 2017; and 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..

Commercial shipping is responsible for a significant noise input into the marine environment. The low frequency nature of shipping noise is not unlike that of seismic, in that it travels long distances underwater. The offshore Taranaki and South Taranaki Bight are frequently used by large ships in transit, hence background shipping noise is likely to be a constant in the Operational Area and both alone and in conjunction with the Western Platform Multi-Client 3D Seismic Survey could cause some masking of cetacean vocalisations.

Despite the potential for cumulative effects to occur, no specific additional mitigation measures are recommended to address these effects.

6.3 Unplanned Events

Unplanned events are rare during seismic survey operations; however, the potential effects of any accidental incident must be given serious consideration as consequences of such events can be severe. The unplanned events associated with seismic operations include the introduction of invasive marine species, streamer loss, hydrocarbon spills or a vessel collision/sinking. These potential incidents are discussed below.

6.3.1 Potential effects of invasive marine species

The introduction and spread of marine pests or invasive species to New Zealand waters can occur through ballast and bilge water discharges, and hull, anchor chain and sea chest fouling (Fletcher et al., 2017). An introduced species is only considered 'invasive' once it begins to cause negative consequences on its new environment (Bax et al., 2003) and once established, marine pests are difficult to manage or eradicate (Fletcher et al., 2017). Potential effects of invasive species include ecological effects such as changes in the functioning and composition of a community, and economic effects on sectors such as aquaculture and tourism (Fletcher et al., 2017).

As part of the environmental management commitments for the proposed Western Platform Multi-Client 3D Seismic Survey, Schlumberger have committed to reduce the risk of introducing invasive marine species by requiring that survey and support vessels arriving from overseas are inspected by qualified invasive marine species inspectors. Based on the outcomes of each inspection, management measures will be implemented to ensure vessels meet the Part 2.1 'clean' hull requirements of the Craft Risk Management Standard – Biofouling on Vessels Arriving to New Zealand. Any survey vessel arriving into New Zealand waters for the Western Platform Multi-Client 3D Seismic Survey will also adhere to the 'Import Standard for Ballast Water Exchange'. The potential risk of introducing invasive marine species is therefore considered to be ***low*** (minor × rare).

6.3.2 Potential effects of streamer loss

There are a number of ways in which potential damage and resultant loss of streamers could occur; these include snagging with floating debris, rupture from abrasions or shark bites, or loss from severance e.g. if another vessel was to accidentally cross the streamer. Solid streamers are negatively buoyant and would sink if severed. Therefore, if a streamer is lost there is potential for the severed portion to litter the seabed.

Despite this potential for damage, solid streamers with self-recovery devices will be used during the Western Platform Multi-Client 3D Seismic Survey. The self-recovery devices are programmed to activate at depth (~ 50 m), bringing the streamer back to the surface for retrieval. This will minimise the potential for damage to benthic communities in the event of streamer loss.

Towed streamers will also 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 streamer.

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. The offshore nature of the Operational Area will therefore reduce any potential for impacts on such values.

The Western Platform Multi-Client 3D 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 ***low*** (negligible × possible).

6.3.3 Potential effects of hydrocarbon spills

A hydrocarbon spill could arise from a number of different causes; a refuelling incident, leaking equipment or storage containers, or hull/fuel tank failure due to a collision or sinking. An accidental spill associated with refuelling at sea is the most likely scenario to cause an environmental effect as the other types of spills would generally be contained on the vessel or be caused by a highly unusual collision or sinking event.

Effects of hydrocarbon spills on the marine environment are well documented and include, but are not limited to direct and indirect toxicity effects, removal and damage to, or exclusion from habitats and other important areas, bioaccumulation in the food chain, disruption of food chains and predator/prey interactions, loss of waterproofing, buoyancy, swimming ability, filtering capabilities, and thermoregulatory abilities from external oiling, and exclusion of users of the marine environment due to contamination/tainting of edible species or altered perception (McConnell, 2014)

Any spill from the seismic vessel's fuel tank would be limited to the total fuel capacity of the vessel, and for this to occur there would have to be a complete failure of the vessel's fuel containment system or a catastrophic failure of hull integrity. Despite this being theoretically possible, the high-tech navigational systems on-board, adherence of the COLREGS and operational procedures aligned with international best practice will ensure that these risks are minimised.

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

During the Western Platform Multi-Client 3D Seismic Survey it is probable that refuelling will be undertaken once or twice at sea from the support vessel. All vessels involved will have a detailed refuelling protocol outlining the required procedures to prevent any incidents. Spills caused by fuel handling mishaps are rare due to well-tested monitoring and management systems. Potential causes for a spill during refuelling could include hose rupture, coupling failures or tank overflow.

During refuelling, the following mitigation actions will be adopted:

- Refuelling will only be undertaken during daylight and when sea conditions are appropriate as determined by the vessel master;
- A job hazard analysis (or equivalent) will be in place and reviewed before each fuel transfer;
- Transfer hoses will be fitted with 'dry-break' couplings (or similar and checked for integrity);
- Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas;

- Refuelling operations will be manned to ensure constant visual monitoring of gauges, hoses, fittings and the sea surface; and
- Radio communications will be maintained between the seismic vessel and support vessel.

In the event that a spill occurs during refuelling, a spill response will initially be undertaken in accordance with the relevant Shipboard Oil Pollution Emergency Plan, and notifications will be provided to Maritime New Zealand and regional councils as required.

Based on the information presented above and the mitigation actions in place, it is considered that the risks of effects from a hydrocarbon spill are ***medium*** (moderate × unlikely).

6.3.4 Potential effects from vessel collision or sinking

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

6.4 Environmental Risk Assessment Summary

A summary of the ERA results is presented in **Table 33**.

Table 33 Summary of ERA Results for the Western Platform Multi-Client 3D Seismic Survey

Effects from Planned Activities	Consequence	Likelihood	Risk Ranking
Presence of seismic vessel and towed equipment – marine mammal effects	Minor	Likely	Medium
Presence of seismic vessel and towed equipment – seabird effects	Negligible	Likely	Low
Presence of seismic vessel and towed equipment – effects on other marine users	Minor	Likely	Medium
Acoustic disturbance – physiological effects on marine mammals	Major	Unlikely	Medium
Acoustic disturbance – physiological effects on seabirds	Minor	Unlikely	Low
Acoustic disturbance – physiological effects on marine reptiles	Minor	Unlikely	Low
Acoustic disturbance – physiological effects on fish	Minor	Unlikely	Low
Acoustic disturbance – physiological effects on cephalopods	Negligible	Occasional	Low
Acoustic disturbance – physiological effects on benthic invertebrates	Negligible	Possible	Low
Acoustic disturbance – physiological effects on plankton	Minor	Likely	Medium
Acoustic disturbance – behavioural effects on marine mammals	Moderate	Possible	Medium
Acoustic disturbance – behavioural effects on seabirds	Negligible	Possible	Low
Acoustic disturbance – behavioural effects on marine reptiles	Minor	Unlikely	Low
Acoustic disturbance – behavioural effects on fish and fisheries	Minor	Likely	Medium
Acoustic disturbance – behavioural effects on cephalopods	Minor	Likely	Medium
Acoustic disturbance – behavioural effects on benthic invertebrates	Minor	Unlikely	Low
Acoustic disturbance – perceptual effects on marine mammals	Moderate	Likely	High
Acoustic disturbance – perceptual effects on fish	Minor	Possible	Medium
Acoustic disturbance – indirect effects on martine mammals	Minor	Likely	Medium
Effects from the discharge of biodegradable waste	Negligible	Possible	Low
Effects from the discharge of non-biodegradable waste	Negligible	Rare	Low
Effects from atmospheric emissions	Negligible	Likely	Low
Effects from Unplanned Events	**Consequence**	**Likelihood**	**Risk Ranking**
Effects from invasive marine species	Minor	Rare	Low
Effects from streamer loss	Negligible	Possible	Low
Effects from hydrocarbon spills	Moderate	Unlikely	Medium
Effects from vessel collision or sinking	Major	Rare	Medium

7 ENVIRONMENTAL MANAGEMENT PLAN

The management of environmental risks is fundamental to the operating philosophy of Schlumberger. The protocols outlined in the MMMP (**Appendix D**) are the primary measures by which Schlumberger proposes to manage environmental risks during the Western Platform Multi-Client 3D Seismic Survey. The MMMP is the operating procedure that is followed by MMOs and the seismic vessel crew 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 Western Platform Multi-Client 3D Seismic Survey. As well as being reflected in the MMMP, these measures are summarised in the Environmental Management Plan (EMP) presented in **Table 34**.

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).

In accordance with the Code of Conduct, and within 60 days following the completion of the Western Platform Multi-Client 3D Seismic Survey, a MMO report is to be submitted to DOC. This report includes all marine mammal observation data recorded during the survey, including where shut downs occurred due to marine mammals within the mitigation zones and the GPS coordinates of each marine mammal sighting. The provision of this information is the primary way in which the Western Platform Multi-Client 3D Seismic Survey will contribute to research, whereby the resulting data is incorporated into the DOC marine mammal sighting database and is then accessible for research purposes by DOC, Universities, or other institutions. In essence, records from the Western Platform Multi-Client 3D Seismic Survey will increase DOC's knowledge of marine mammals in the Taranaki Basin.

New Zealand is a hotspot for marine mammal strandings. Since 1840, more than 5,000 strandings of whales and dolphins have been recorded around the New Zealand coast. During any stranding event, DOC is responsible for all aspects of stranding management including whether or not a necropsy will be undertaken to investigate the cause of death. Due to public concerns about possible links between marine mammals 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. If a marine mammal is found inshore of the Operational Area during the survey and for a period of two weeks after the Western Platform Multi-Client 3D Seismic Survey, Schlumberger in discussions with DOC will consider covering the costs associated with a necropsy. Resulting necropsy data would be of benefit to the scientific community.

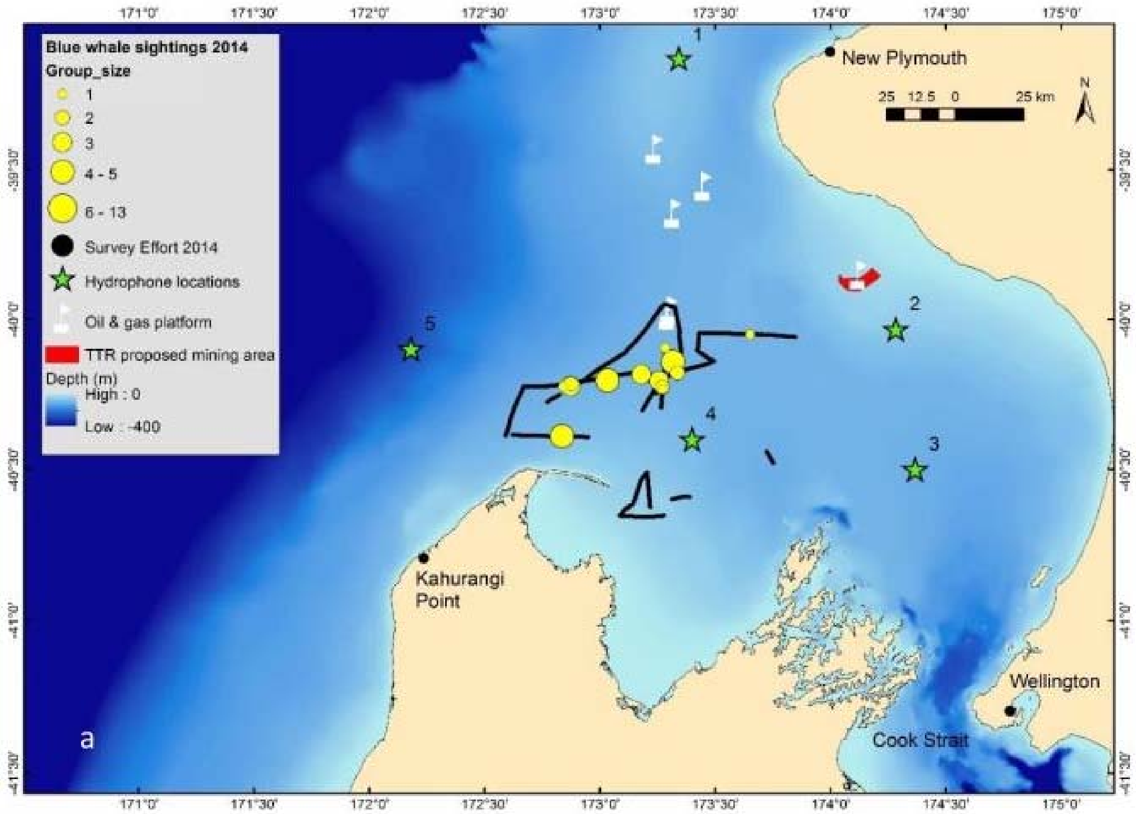
With regard to other marine mammal research in the vicinity of the Operational Area, the following projects should be noted:

- 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. There is no direct spatial overlap between these deployments and the Western Platform Multi-Client 3D Seismic Survey;
- NIWA also has six hydrophones deployed in the Cook Strait region. This project is detecting whale vocalisations to better understand what species utilise this region throughout the year. Four of these hydrophones are deployed on the eastern approach to Cook Strait, with only two on the western approach (both inshore of the Operational Area) (K. Goetz, pers. comm.). There is no direct spatial overlap between these deployments and the Western Platform Multi-Client 3D Seismic Survey; 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 30** until January or February 2018 (at which time they will be retrieved) (L. Torres pers. comm.). Spatial overlap is apparent between some of these hydrophones and the Operational Area for the Western Platform Multi-Client 3D Seismic Survey. Mooring location 1 is certainly in the Operational Area, with mooring numbers 2 and 4 being close to the Operational Area boundary. Where possible MMO sightings records of blue whales and any associated photos will be provided to Oregon State University at the conclusion of the Western Platform Multi-Client 3D Seismic Survey.

All of the institutes involved in the research activities above have been contacted during the engagement process and are aware of the proposed Western Platform Multi-Client 3D Seismic Survey.

Figure 30 Oregon State University Hydrophone Locations (green stars)



Source: Torres et al., 2017

Table 34 Western Platform Multi-Client 3D 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 3 months • 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 • North-south acquisition lines give a period of relief from masking every 24 hrs and encourage plankton replenishment • The majority of operations are outside the CMA, hence effects on coastal species and shellfish larvae will be minimised • 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 3 months • 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 • The majority of operations are outside the CMA, hence effects on recreational fish stocks species will be minimised	COLREGS International best practice
Minimise potential of invasive species	• Survey vessels arriving from overseas to be inspected by qualified invasive marine species inspectors • Adherence to Craft Risk Management Standard for Vessel Biofouling (CRMS) • Adherence to Import Health Standard for Ships Ballast Water (IHS)	Biosecurity Act 1993 IHS CRMS
Minimise effects on water quality	• All discharges to sea will occur in accordance with MARPOL and relevant NZ legislation • On-board sewage treatment plant and approved ISPPC as applicable • On-board bilge water treatment plant to ensure oily water discharge does not exceed 15 ppm • All non-biodegradable waste to be returned to shore for disposed at an approved shore reception facility • Schlumberger will ensure that a waste disposal log is maintained on all survey vessels	MARPOL Annex V and IV Maritime Transport Act 1994 Marine Protection Rules Part 170 EEZ Discharge & Dumping Regulations 2015 Resource Management (Mar Pol) Regulations 1998
Minimise effects on air quality	• Regular maintenance of machinery • Approved IAPPC where applicable to vessel class and regular monitoring of fuel consumption	International best practice
Minimise the likelihood of unplanned events	• 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 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 • The M/V Amazon Warrior will receive an iwi blessing before the survey commences • Iwi will be updated on any non-compliance issues as they arise and post survey engagement will occur • Post-survey bathymetry information was offered to stakeholder groups	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. During the proposed Western Platform Multi-Client 3D Seismic Survey, Schlumberger will comply with the Code of Conduct as the primary means of mitigating its environmental effects. 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, behavioural and perceptual effects during the Western Platform Multi-Client 3D Seismic Survey.

Schlumberger will have two MMO’s and two PAM operators on-board the seismic vessel and an additional iwi trainee on each swing. These personnel will be independent and qualified through DOC accredited training programmes. Visual observations will occur through daylight hours when the source is in the water and PAM operations, to acoustically detect marine mammals, will occur around the clock to enable marine mammal detections to continue at night. Marine mammal detections will trigger the required mitigation action, e.g. delayed start or shut down of the source.

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

This MMIA identifies all potential environmental effects from the Western Platform Multi-Client 3D Seismic Survey and describes the 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 on marine mammal impacts, potential effects on other components of the marine ecosystem and existing maritime activities are also considered and assessed through well-established ERA methodologies.

In summary, the predicted effects of the Western Platform Multi-Client 3D Seismic Survey are generally considered to be ***low to medium***, with medium effects representing a small environmental impact that is sufficiently managed by the proposed mitigation measures. There is however a ***high*** risk of auditory masking of marine mammals (particularly blue whales in South Taranaki Bight); however the long acquisition lines will provide a period of relative relief from masking every 24 hours.

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.

Arnold, S., 2004. '*Shining a Spotlight on the Biodiversity of New Zealand's Marine Ecoregion*'. Experts workshop on Marine Biodiversity, 27-28 May 2003, Wellington, New Zealand.

Aroyan, 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.

AWE, 2017. '*Tui Area Oil Project*'. http://www.awexplore.com/irm/content/tui-area-oil-project.aspx?RID=413

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.

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.

Baumgartner, M., Van Parijs, S., Wenzel, F., Tremblay, C., Esch, H.C., Warde, A., 2008. '*Low frequency vocalisations attributed to sei whales (Balaenoptera borealis)*'. Journal of the Acoustical Society of America 124(2): 1339-1349.

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.

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., 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.

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, 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.

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

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.

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.

Davidson, R.J., and Richards, L.A 2013. '*Tonga Island Marine Reserve, Abel Tasman National Park: Update of Biological Monitoring, 1993 – 2013*'. Prepared by Davidson Environmental Limited for the Department of Conservation, Nelson. Survey and Monitoring Report No. 771.

Davidson, R., Duffy, C., Gaze, P., Baxter, A., DuFresne, S., Courtney, S., Hamill, P 2011, "*Ecologically Significant Marine Sites in Marlborough, New Zealand"*, Co-ordinated by Davidson Environmental Limited for Marlborough District Council and Department of Conservation.

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

Day, R.d., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M. 2016 '*Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries'*. 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.

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

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

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

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

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

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

DOC, 2017g. '*Parininihi Marine Reserve'*. http://www.doc.govt.nz/parks-and-recreation/places-to-go/taranaki/places/parininihi-marine-reserve/

DOC, 2017h. '*Tapuae Marine Reserve'*. http://www.doc.govt.nz/parks-and-recreation/places-to-go/taranaki/places/tapuae-marine-reserve/

DOC, 2017i. 'Horoirangi Marine Reserve'. http://www.doc.govt.nz/parks-and-recreation/places-to-go/nelson-tasman/places/horoirangi-marine-reserve/

DOC, 2017j. '*Tonga Island Marine Reserve'*. http://www.doc.govt.nz/parks-and-recreation/places-to-go/nelson-tasman/places/tonga-island-marine-reserve/

DOC, 2017k. '*Westhaven (Whanganui Inlet) Area'*. http://www.doc.govt.nz/parks-and-recreation/places-to-go/nelson-tasman/places/westhaven-whanganui-inlet-area/

DOC, 2017l. *'Nga Motu/Sugar Loaf Islands Marine Protected Area*'. http://www.doc.govt.nz/parks-and-recreation/places-to-go/taranaki/places/nga-motu-sugar-loaf-islands/

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

DOC, 2017n. '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

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, 2015. '*New Zealand Seabirds: Sites on Land, Coastal Sites and Islands'*. The Royal Forest and Bird Protection Society of New Zealand, Wellington, New Zealand, pp. 250.

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.

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

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.

Gausland, I 2003. "*Seismic surveys impact on fish and fisheries*". Report for Norwegian Oil Industry Association (OLF).

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. 2015. '*Statement of Evidence of Nicola Gay Gibbs for Shell Todd Oil Services Ltd*', 17 March 2015. Marine Consent Hearing – Applicants Evidence:

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.

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.

Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K.A., Karkzmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y. , Wells, R.S. & Wilson, B. 2012. Lissodelphis peronii. The IUCN Red List of Threatened Species 2012: e.T12126A17877993. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T12126A17877993.en. Downloaded on 20 July 2017.

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.

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.

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 seal*". Marine Ecology Progress Series 227: 11–24.

Harcourt, R.G 2001, "*Advances in New Zealand mammalogy 1990 – 2000: Pinnipeds",* Journal of the Royal Society of New Zealand 31: 135 – 160.

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.

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

Horwood, J 2009, "Sei whale *Balaenoptera borealis*. In, Perrin,W.F.; Würsig, B.G.; Thewissen, J.G.M. (Eds.), Encyclopaedia of marine mammals", pp. 1001–1003. Academic Press, United States

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.

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

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, JA., Steel, DJ., Beerli, P., Congdon, BC., Olavarria, C., Leslie, MS., Pomilla, C., Rosenbaum, H., Baker, C 2014. *Global diversity and oceanic divergence of humpback whales (Megaptera novaeangliae*). Proceedings of the Royal Society B 281: 20133222

Jackson, J., 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., Newcomer, M. W., Leatherwood, S. and Van Waerebeek, K. 1994. Right whale dolphins *Lissodelphis borealis* (Peale, 1848) and *Lissodelphis peronii* (Lacepede, 1804). In: S. H. Ridgway and R. Harrison (eds), Handbook of marine mammals, pp. 335-362. Academic Press.

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.

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

Kawhia Maori History 2015. http://www.kawhia.maori.nz/

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., 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.

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.

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.

McClary, D. 2014. Statement of Evidence in Chief of Dr Dan McClary on behalf of Trans-Tasman Resources Ltd. 17 February 2014.
http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_24_Dan%20McClary_(Ecological%20effects).PDF

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.

McDonald, M., Hildebrand, J., Mesnick, S. 2009. "W*orldwide decline in tonal frequencies of blue whale songs*". Endangered Species Research 9: 13-21.

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., 2011. '*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.

MetOcean Solutions Ltd, 2013. '*Oil Spill Trajectory Modelling – Assessment of Potential Coastal Impacts with Simulation of Surface Release from Proposed Well at Pateke-4H*'. Prepared for AWE, MetOcean Solutions Report:P0149-01, pp.42.

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.

MfE, 2017. '*Section 5: Recreational Fishing Parks'.* https://www.mfe.govt.nz/publications/marine/new-marine-protected-areas-act-consultation-document/section-5recreational

Miller, B. S., Collins, K., Barlow, J., Calderan, S., Leaper, R., McDonald, M., Ensor, P., Olson, P., Olavarria, C., Double, M. C 2013, "*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.

Mizroch, S. A., Rice, D.W., Breiwick, J.M 1984, "*The sei whale, Balaenoptera physalus*", Marine Fisheries Review 46 (4): 20 – 24

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.

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

MPI, 2017b. '*Temporary Closure of the Southern Scallop (SCA 7) Fishery – Discussion Document'.* Prepared for public consultation by the Ministry for Primary Industries, MPI Discussion Paper No: 2017/19, pp17.

NCC 2004. *Nelson Resource Management Plan*. http://nelson.govt.nz/environment/nelson-resource-management-plan/nelson-resource-management-plan-2/view-the-nrmp/download-the-nrmp-2/

Nelms, S., Piniak, W., Weir, C., Godley, B., 2016. '*Seismic Surveys And Marine Turtles: An Underestimated Global Threat?*'. Biological Conservation 193: 49-65.

New Zealand Birds Online 2015. http://nzbirdsonline.org.nz/

Nga Uri O Tahinga Trust 2012, "*Tahinga Environmental Management Plan*"

Ngāti Mutunga Iwi 2014. *Ngāti Mutunga Tribal Area*. http://ngatimutunga.iwi.nz/tribal-area/

NIWA, 2017. '*Tuna – Spawning Grounds'*. https://www.niwa.co.nz/te-k%C5%ABwaha/tuna-information-resource/biology-and-ecology/spawning-grounds

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 Basins*', 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.

Ocean Research Group 2015, "*Sperm Whales*", http://www.oceanicresearch.org/education/wonders/spermwhales.htm

Offshore Technology, 2017. '*Maari Oil Field, New Zealand'*. http://www.offshore-technology.com/projects/maarioilfieldnewzeal/

Offshore Technology, 2017a. '*Pohokura Field New Zealand'.* http://www.offshore-technology.com/projects/pohokurafieldnewzeal/

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.

Orpin, A.R., 2015. '*Geological Desktop Summary; Active Permit Areas 50753 (55581), 54068 and 54272, South Taranaki Bight'*. Prepared for Trans-Tasman Resources Ltd, NIWA Client Report No: WLG2013-44.

Oshumi, S., Kasamatsu, F 1986, "*Recent off-shore distribution of the southern right whale in summer*", Reports of the International Whaling Commission Special Issue 10: 177-186.

Parker, N., Mladenov, P., Grange, K 1997. "*Reproductive biology of the antipatharian black coral Antipathes fiodensis* in Doubtful Sound, Fiordland, New Zealand". Marine Biology, 130: 11-22.

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.

Pitman, R. L., 2002. '*Mesoplodont whales Mesoplodon spp. In: W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), Encyclopaedia of Marine Mammals*;. pp. 738-742. Academic Press.

Pickett, G., Eaton, D., Seaby, R., Arnold, G 1994. *Results of bass tagging in Poole Bay during 1992*. Ministry of Agriculture Fisheries and Food.

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., Slooten, E., Webster, T 2012. "Distribution of southern right whales on the Auckland Island calving grounds", New Zealand Journal of Marine and Freshwater Research 46: 431 – 436.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N 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 2008b. *Balaenoptera borealis*. The IUCN Red List of Threatened Species 2008: e.T2475A9445100. . 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 AJ, Matear RJ and 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.

Robertson, B., and Stevens, L 2012. *Tasman Coast: Waimea Inlet to Kahurangi Point – Habitat Mapping, Ecological Risk Assessment and Monitoring Recommendations*. Prepared for Tasman District Council. Tasman District Council Report Ref: 12002.

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.

RPS, 2014. '*Māui Field – South Taranaki Basin Quantitative Spill Modelling Study'*. Prepared for ERM, Report No: Q0314, pp.1002.

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.

Scholik, A., Yan, H 2002. "*Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimphales promelas*". Environmental biology of fishes, 63, 203-209.

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.

Scofield, P., Stephenson, B 2013. *Birds of New Zealand: A photographic Guide*. Auckland University Press, Auckland, New Zealand.

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.

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.

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.

STOS, 2017. '*Maui'.* http://www.stos.co.nz/maui.asp

STOS, 2017a *"Pohokura'.* http://www.stos.co.nz/pohokura.asp

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., 2008b. '*Mesoplodon ginkgodens. The IUCN Red List of Threatened Species 2008: e.T13246A3427970*'. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T13246A3427970.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, 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

Te Tau Ihu 2014. *Te Tau Ihu Statutory Acknowledgements 2014*. Statutory Acknowledgements of the Resource Management Plans for Marlborough District Council, Nelson City Council and Tasman District Council.

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., 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., Gill, P., Hamner, R., Glasgow, D., 2014. '*Documentation of a Blue Whale Foraging Ground in the South Taranaki Bight'*. Prepared for DOC, OSU, IFAW, Greenpeace NZ and Todd Energy, NIWA Client Report: WLG2014-17.

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.

TRC 1997. *Regional Coastal Plan for Taranaki.* http://www.trc.govt.nz/coastal-plan-index/

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/

Van Ginkel, C., Becker, D., Gowans, S & Simard, P. 2017. Whistling in a noisy ocean: bottlenose dolphins adjust whistle frequencies in response to real-time ambient noise levels. Bioacoustics 2017. https://doi.org/10.1080/09524622.2017.1359670

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.

Waikato Regional Council, 2005. *Waikato Regional Coastal Plan*. Prepared by Policy & Transport Group for Waikato Regional Council. Document #2190276.

Waikato Regional Council, 2017. '*Coasts*'*.* https://www.waikatoregion.govt.nz/environment/natural-resources/coast/

Waikato-Tainui 2013. *Waikato-Tainui Environmental Management Plan*. http://www.wrrt.co.nz/wp-content/uploads/EBook_FINAL_EP_Plan_sp.pdf

Wakefield, A.T., Walker, L., 2005. '*Maori Methods and Indicators for Marine Protection: Ngati Kere Interests and Expectations for the Rohe Moana'*. New Zealand Department of Conservation, Ngati Kere and Ministry for the Environment, Wellington, New Zealand. 66 p.

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. and Dawson, S 2011. *The vocal repertoire of the Southern right whale in New Zealand waters.* Poster presentation at 19th Biennial conference on the Biology of Marine Mammals, Tampa, USA, November 2011. http://whaledolphintrust.org.nz/projects/southern-right-whales/

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.

Sound Transmission Loss Modelling Report

Schlumberger New Zealand Limited

Taranaki Basin 3D Seismic Survey

Sound Transmission Loss Modelling

Report Number 740.10032.AU300

20 September 2017

Schlumberger New Zealand Limited
94 Paraite Road
New Plymouth 4373
New Zealand

Version: v1.0

Schlumberger New Zealand Limited

Taranaki Basin 3D Seismic Survey

Sound Transmission Loss Modelling

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
589 Hay Street
Jolimont 6014 Australia

+61 8 9422 5900   +61 8 9422 5901
perth@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
740.10032.AU300	v1.0	20 September 2017			

Executive Summary

Schlumberger New Zealand Ltd (SLB) is proposing to acquire a three dimensional (3D) multi-client marine seismic survey in the Taranaki Basin. SLR Consulting New Zealand Pty Ltd (SLR) has been engaged by SLB to provide a Marine Mammal Impact Assessment (MMIA) and the requisite Sound Transmission Loss Modelling (STLM) services for the proposed seismic survey, to assist SLB 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. West Coast North Island Marine Mammal Sanctuary).

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

The acoustic source array configuration that will be used for the Taranaki Basin seismic survey is the 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 two selected source locations. However, at the two selected source locations, maximum received SELs are 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 as high as 110 dB re 1µPa^2·s, which is the highest received SEL at 200 km among all azimuths. The West Coast North Island Marine Mammal Sanctuary is approximately 1.0 km from the selected long range source location. The maximum SELs received from the selected source location at the sanctuary boundary are predicted to be up to 170 dB re 1µPa^2·s.

Table of Contents

TABLES

Table of Contents

Table of Contents

APPENDICES

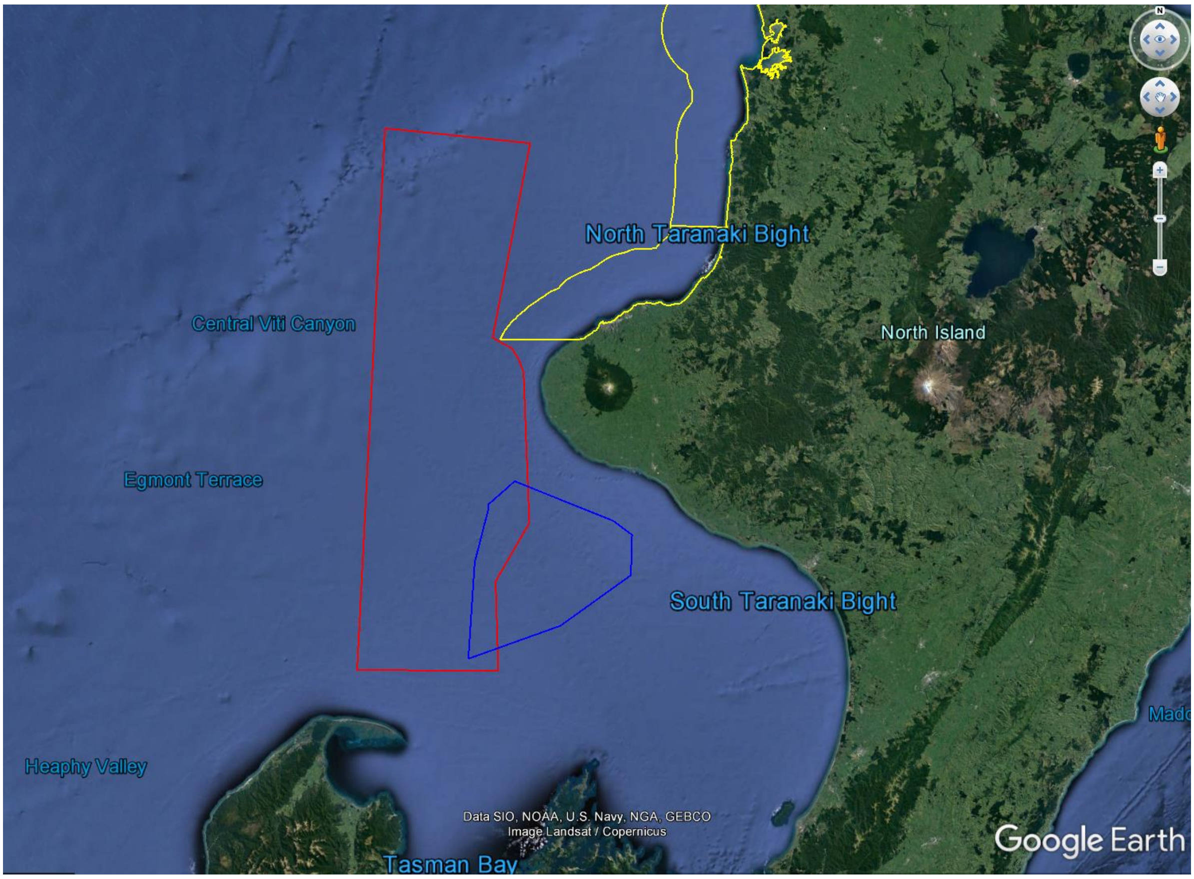
1 INTRODUCTION

1.1 Project description

Schlumberger New Zealand Ltd (SLB) is proposing to acquire a three dimensional (3D) multi-client marine seismic survey in the Taranaki Basin. The 'Taranaki Basin 3D Multi-Client Seismic Survey' is located off the west coast of central and southern North Island, with the survey Operational Area shown in **Figure 1**. The survey will be comprised of the main offshore acquisition area (red polygon in **Figure 1)** and an additional single survey tie-line which will run into shallow waters near the Kupe Field (blue polygon in **Figure 1)**. The overall Operational Area is therefore defined by the collective area encompassed by both the red and blue polygons presented in **Figure 1.** SLB is planning to undertake this survey in the fourth quarter of 2017, with a proposed start date of 1 December 2017.

SLR Consulting NZ Ltd (SLR) has been engaged by SLB to undertake Sound Transmission Loss Modelling (STLM) for the proposed survey, in order to predict the received Sound Exposure Levels (SELs) from the survey. The modelling outputs will also be used to demonstrate whether the survey complies with the SEL statutory requirements within the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) (DOC, 2013).

Figure 1 The Operational Area of the proposed 3D Multi-client seismic survey in red, and that of the additional survey line in blue. Yellow polygon indicates the adjacent West Coast North Island Marine Mammal Sanctuary.



1.2 Statutory requirements for sound transmission loss modelling (STLM)

In New Zealand, the *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) was developed by the Department of Conservation (DOC) in consultation with a broad range of stakeholders in marine seismic survey operations. The Code came into effect on 29 November 2013.

Schlumberger New Zealand Limited

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. West Coast North Island Marine Mammal Sanctuary).

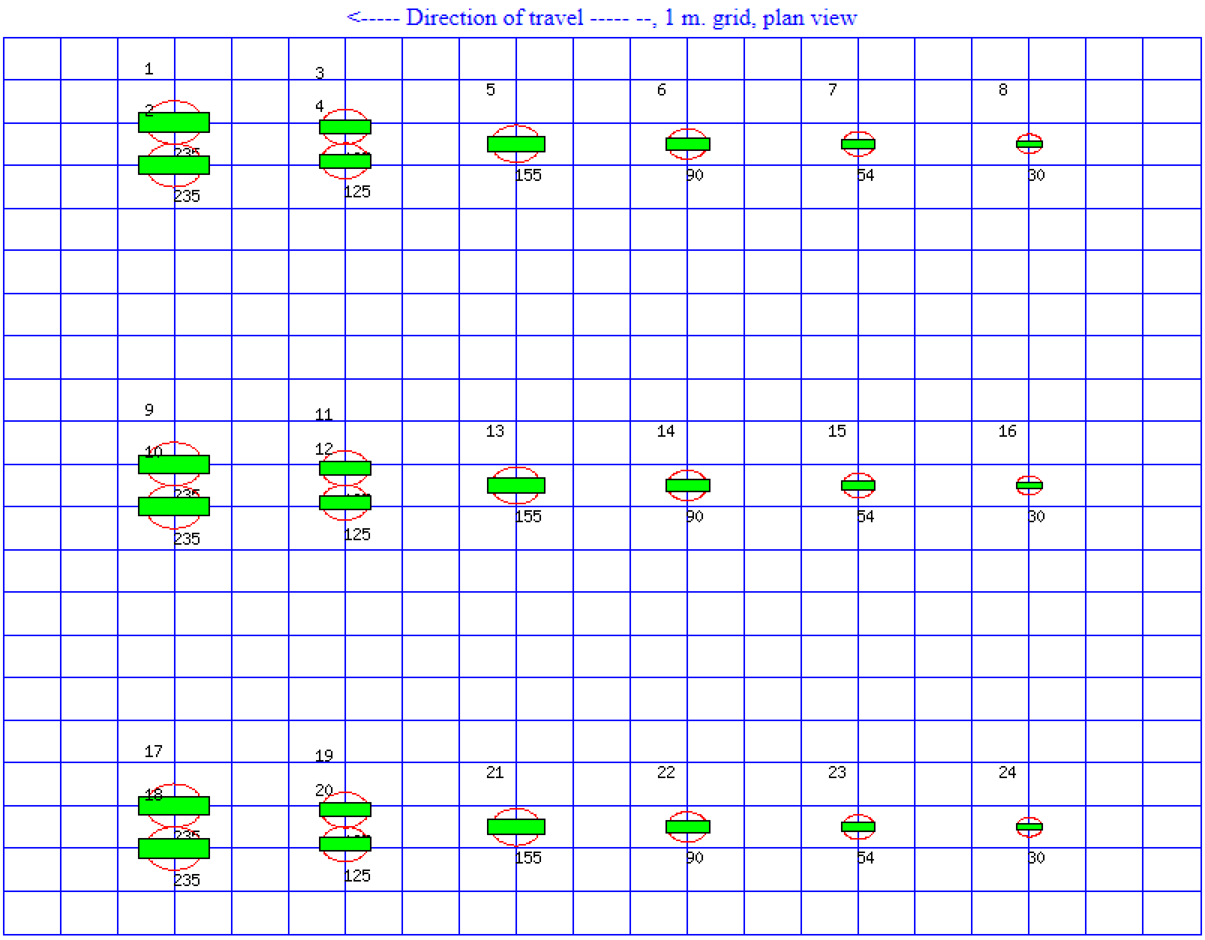
Section 2 of this report details the modelling methodology, procedure and results for the array source modelling. **Section 3** outlines the methodologies and procedures associated with the short and long range transmission loss modelling, with the major modelling results presented in **Section 4**. 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 the Taranaki Basin 3D Multi-Client Seismic Survey is the 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.



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:

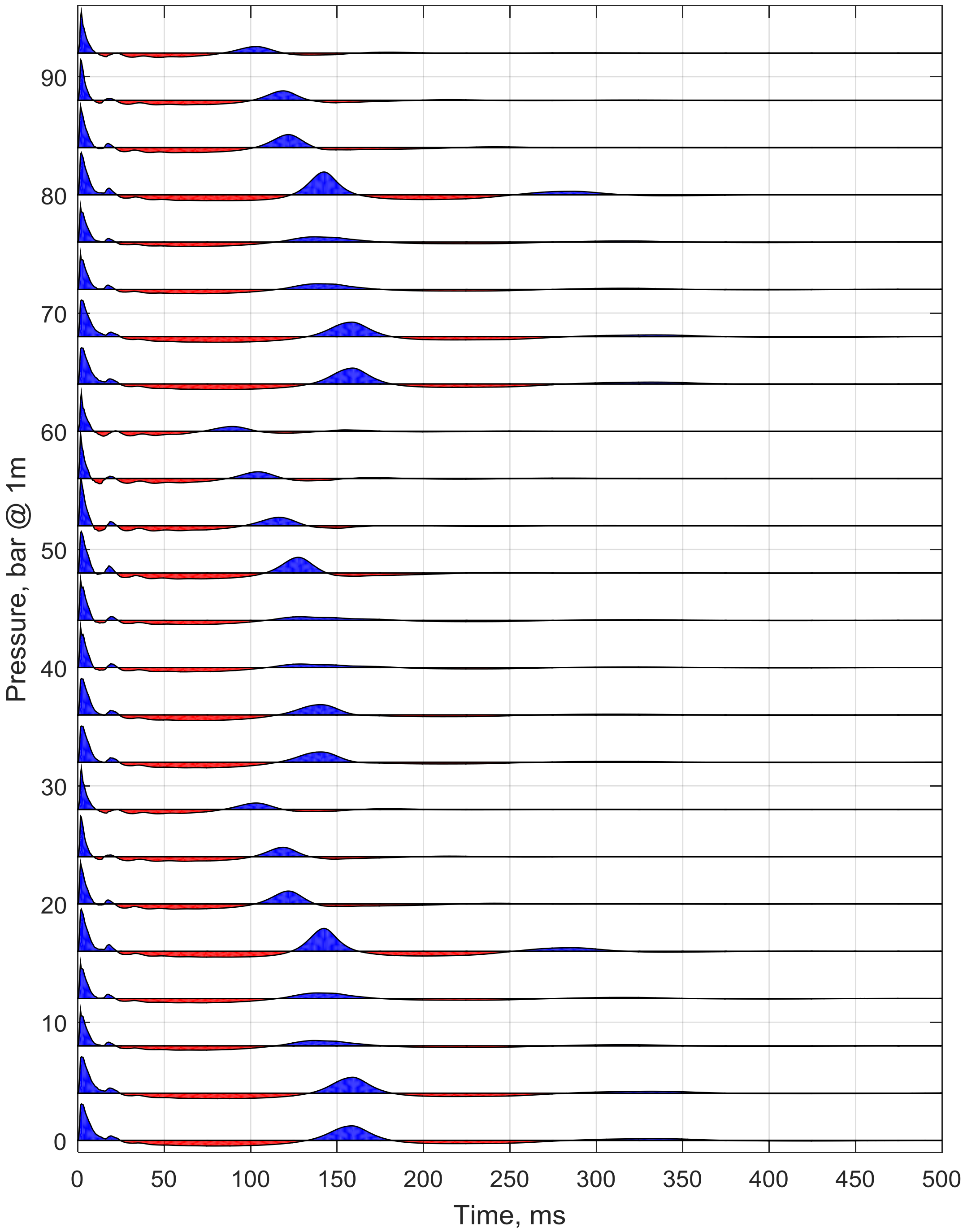
- The far-field signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The power spectral density (PSD) (dB re 1 $\mu Pa^2 s/Hz$ @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of all resulting signature waveforms are combined to form the frequency-dependent beam pattern for the array.

2.3 Modelling results

2.3.1 Notional signatures

Figure 3 shows the notional signatures for the 24 acoustic sources (eight acoustic sources per subarray) of the Boltgun 5,085 cubic inch array.

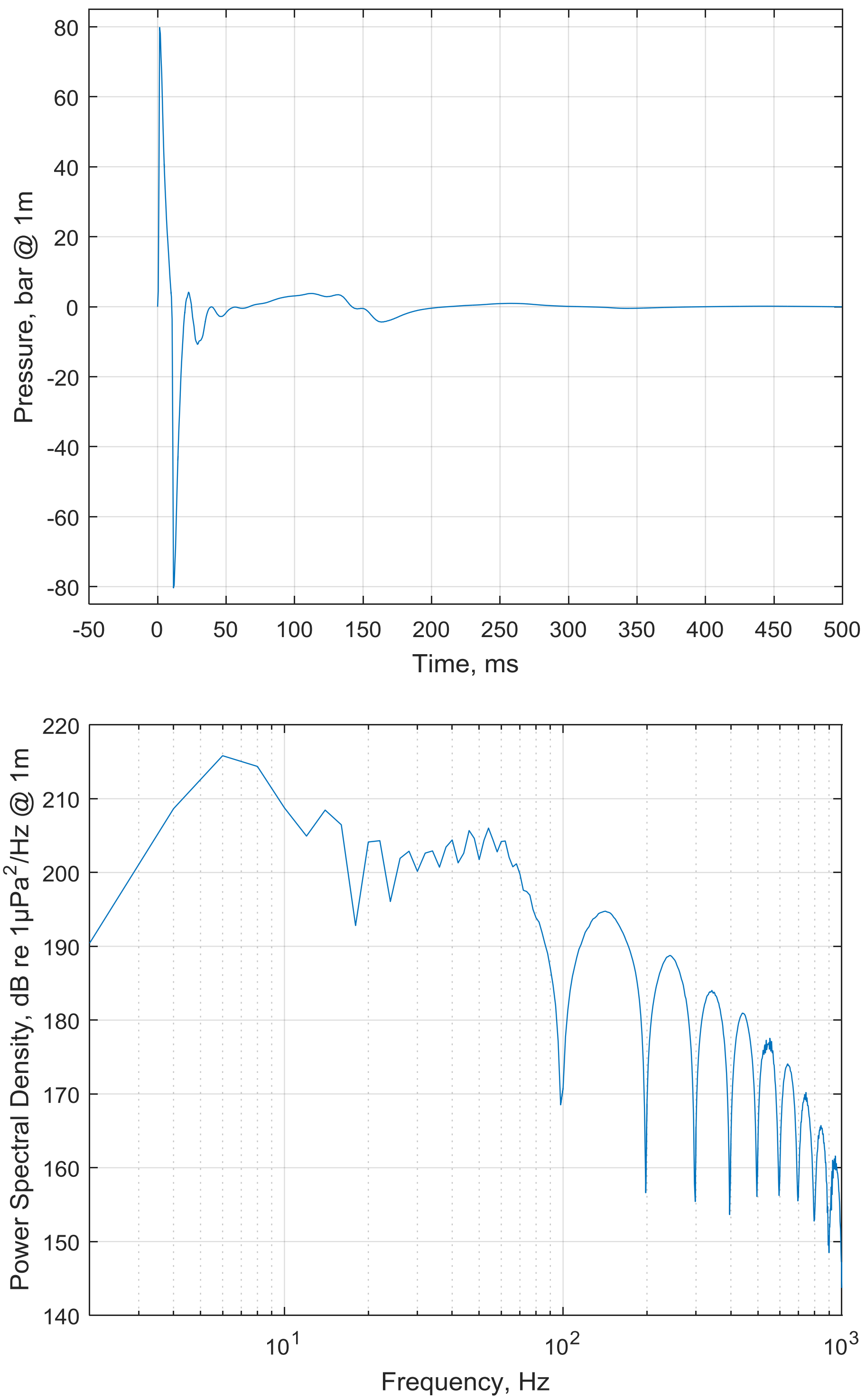
Figure 3 **Notional source signatures for each individual acoustic source within the 24-acoustic source (3 sub-arrays) Boltgun 5,085 cubic inch array. Time series of positive pressure and negative pressure indicated by blue fill and red fill respectively. The scale is the same for the signatures from 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.



Schlumberger New Zealand Limited

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;

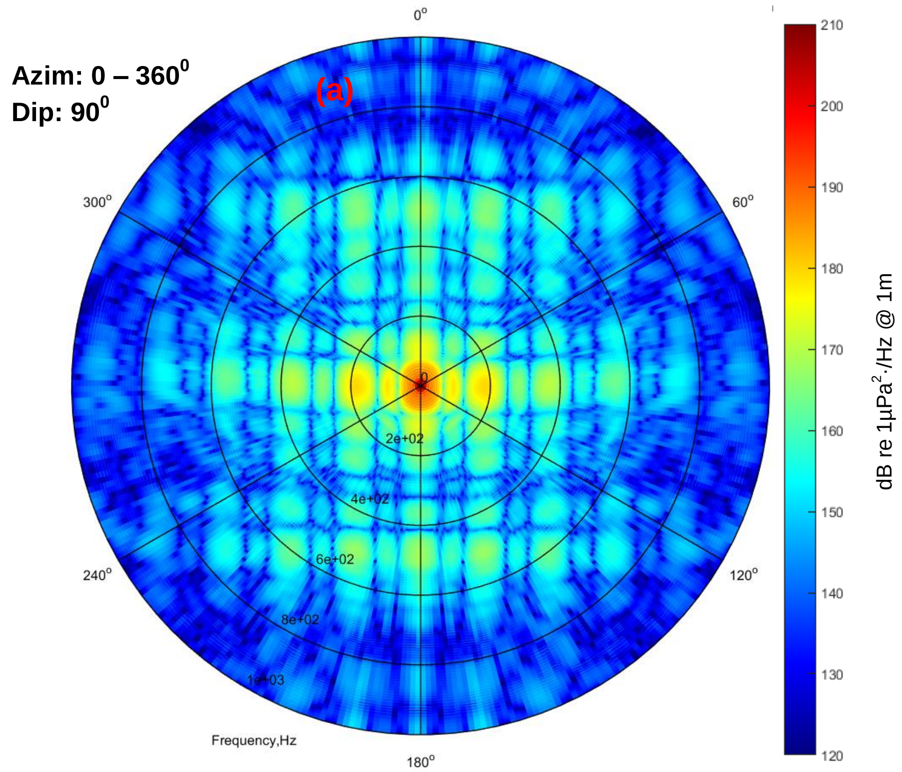
b) The vertical plane for the in-line direction (i.e. azimuthal angle of 0 degree) with dip angle of 0 degree corresponding to the vertically downward direction; and

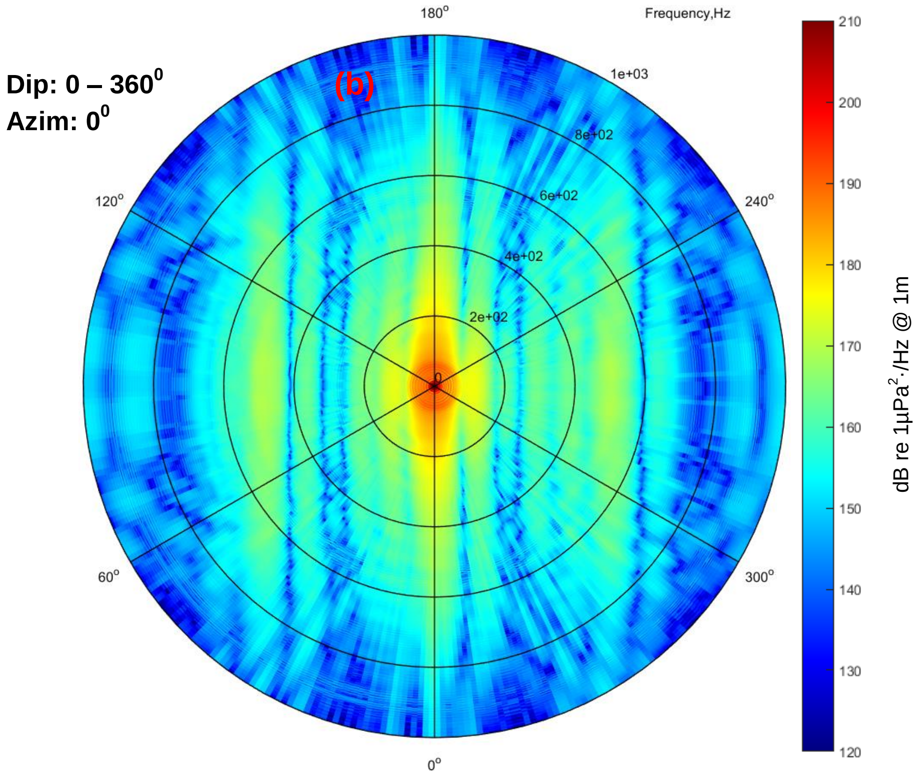
c) The vertical plane for the cross-line direction (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

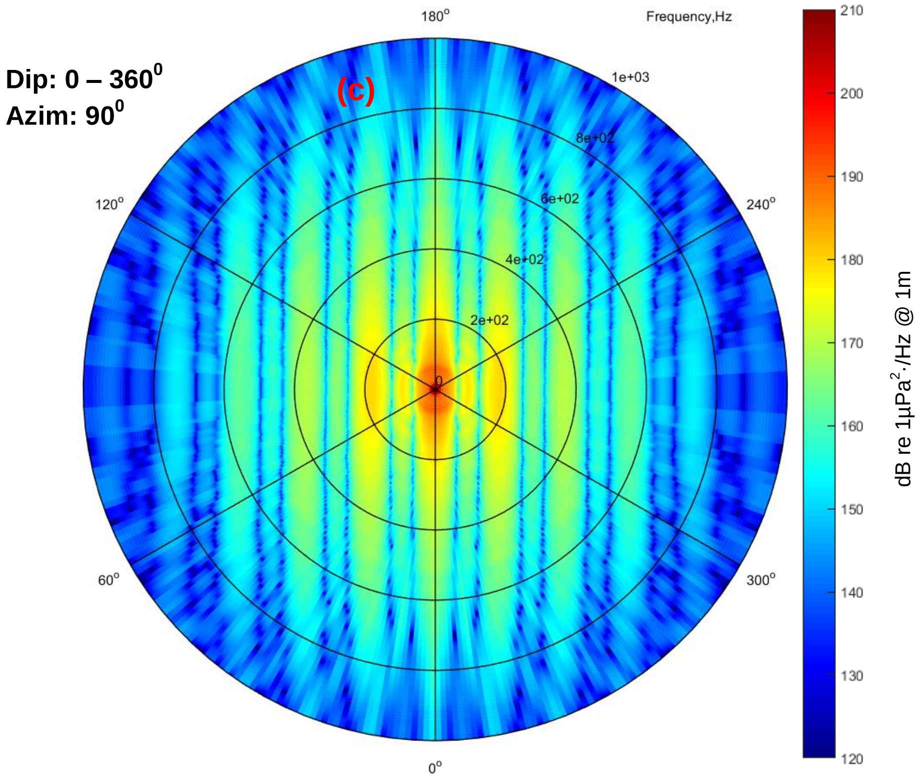
The beam patterns in **Figure 5** illustrate the strong angle and frequency dependence of the energy radiation from the array. The beam pattern of the horizontal plane shows relatively stronger energy radiation in the cross-line direction than in the in-line direction. The beam patterns of the in-line 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

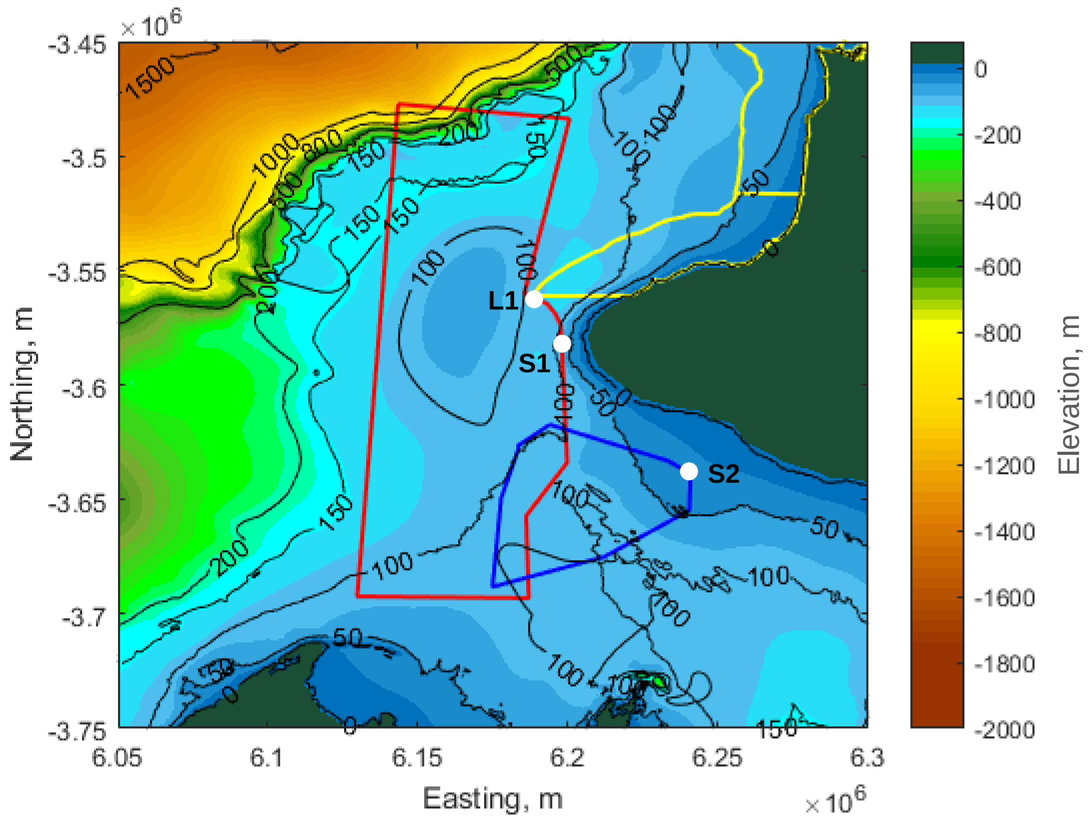
3.1 Modelling input parameters

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 locations S1 and S2 were selected on the basis of bathymetry; where these points represent the shallowest water depths within the main offshore acquisition area (80 m) and the eastern extension for the additional survey tie-line (30 m) respectively. The long-range modelling location L1 was selected because of its proximity to the West Coast North Island Marine Mammal Sanctuary and its relatively shallow water depth (109 m).

Figure 6 The bathymetric imagery in a resolution of 250 m covering the permit area. The coordinate system is based on Web Mercator Map Projection. Yellow polygon shows the marine mammal sanctuary, red polygons are the areas of the proposed 3D seismic survey, and blue polygons the of the additional survey tie-line. White dots indicate the selected source locations for the short range (S1 & S2) and long range (L1) modelling cases.



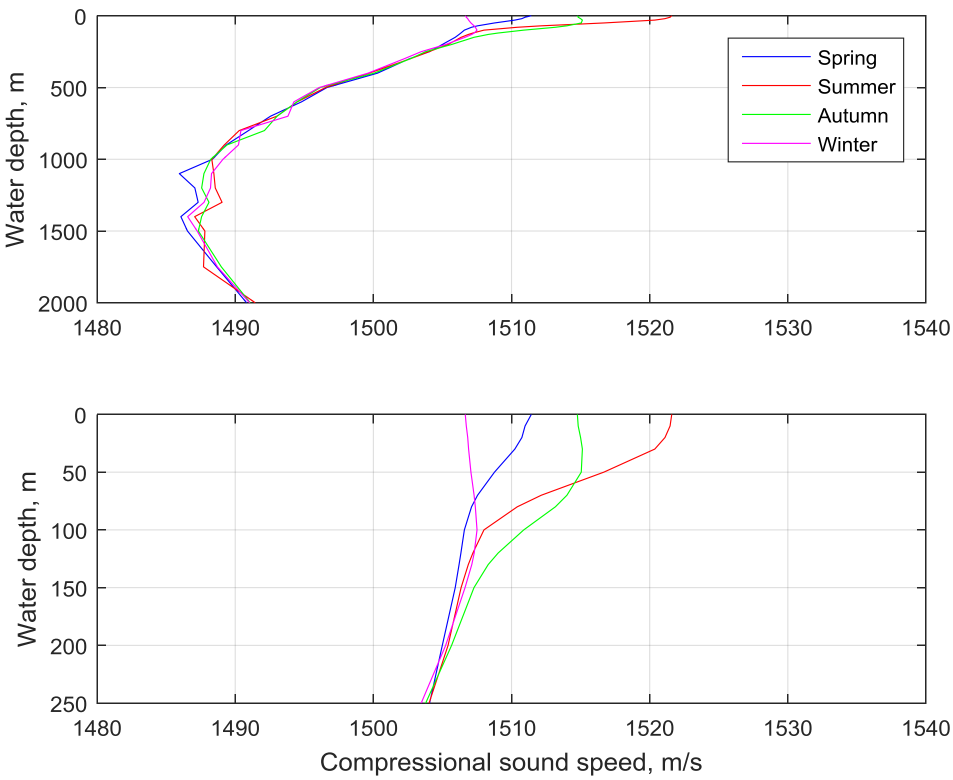
3.1.2 Sound speed profiles

Temperature and salinity data required to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (WOA09) (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure 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 close proximity to the survey area 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 SLB survey is scheduled to occur in the fourth quarter of 2017, with a proposed start date of 1 December 2017. Therefore, the sound speed profile of the summer season has been selected for all scenarios in this modelling study.

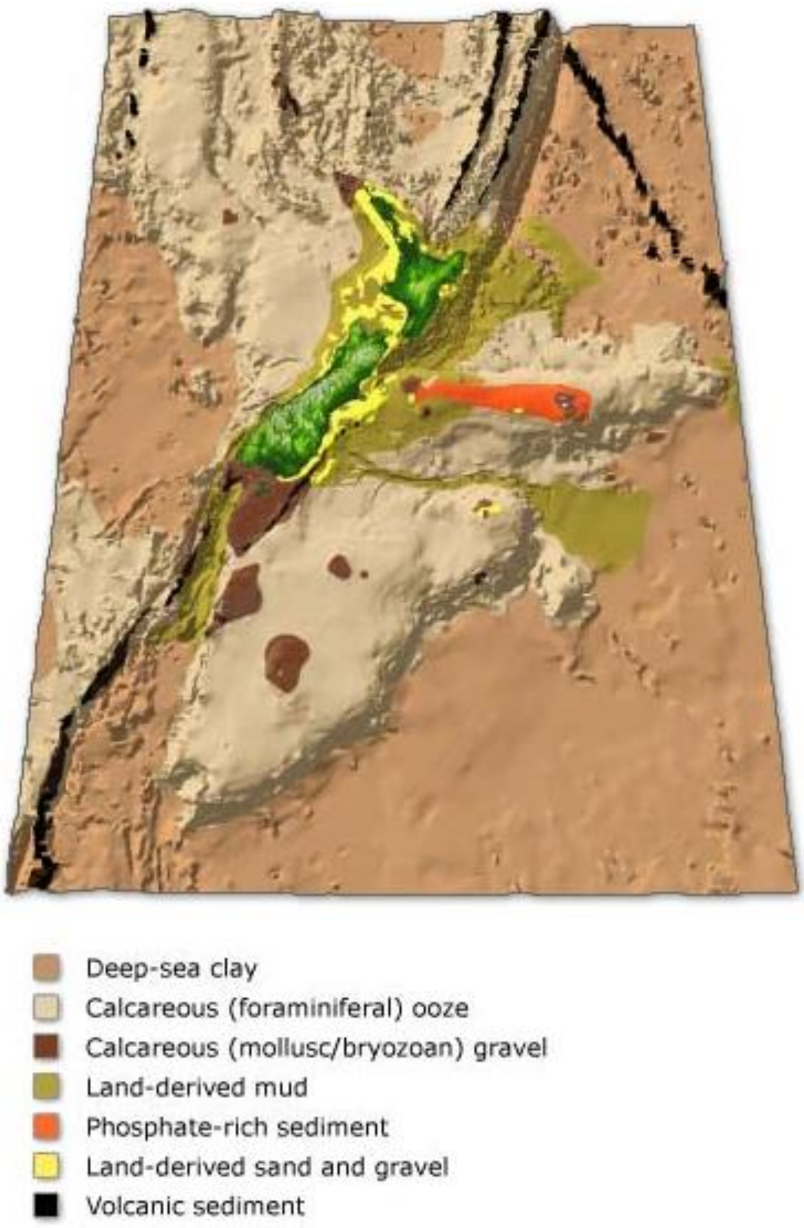
Figure 7 Typical sound speed profiles west of the North Island for different southern hemisphere seasons. Top panel shows profiles in deep water region, bottom panel shows profiles in the continental shelf within the Operational Area.



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 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)

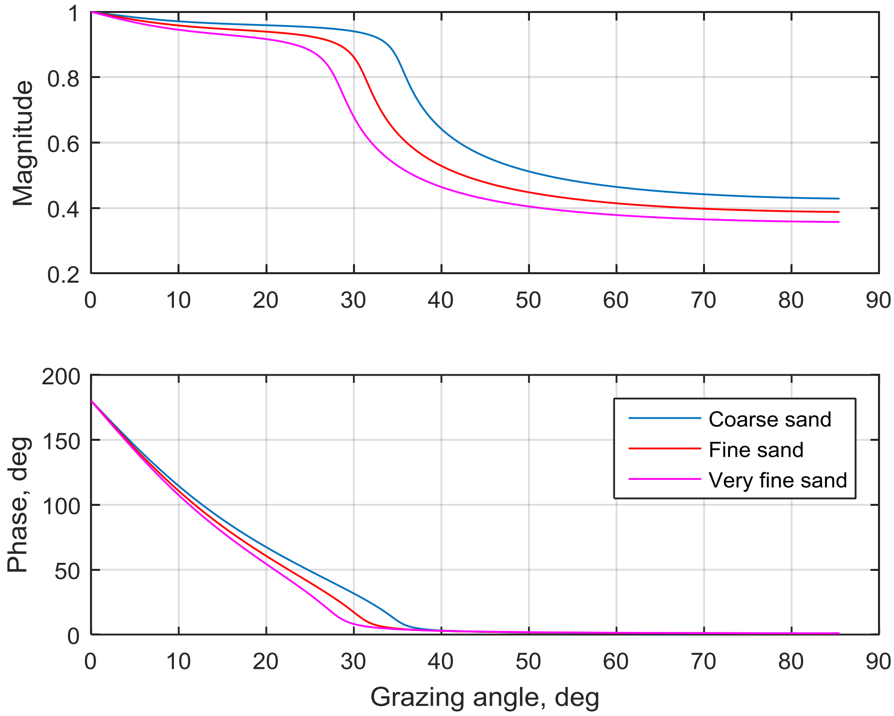
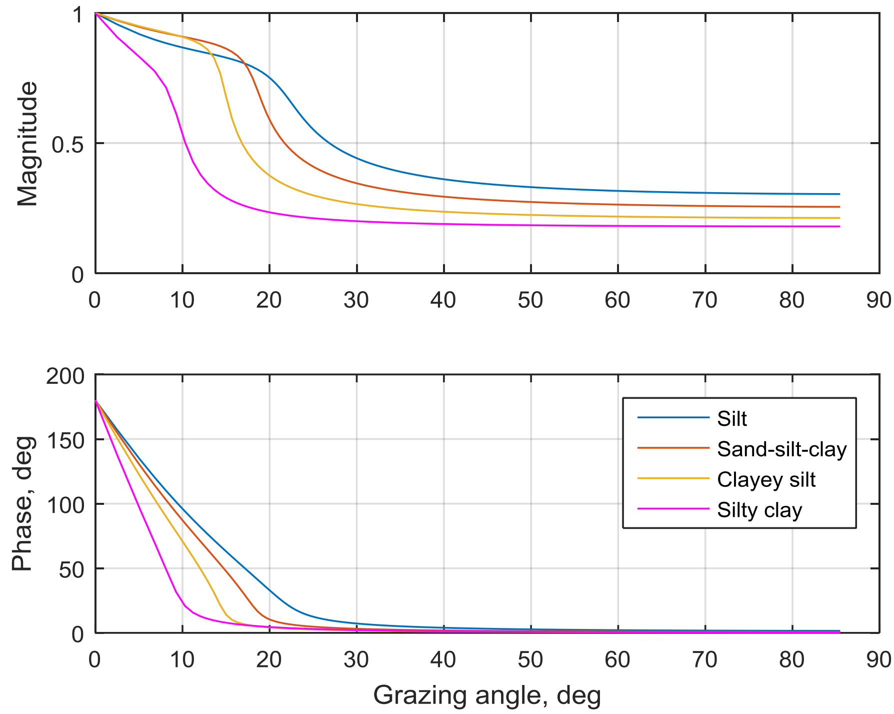


Figure 10 The reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay)



3.2 Detailed modelling methodologies and procedures

The 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:

1) 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);

2) The range from each acoustic source in the array to each receiver is calculated, and the transfer function between each acoustic source and the receiver is obtained by interpolation of the results produced by modelling algorithm SCOOTER in Step 1). This interpolation involves both amplitude and phase of the transfer function;

3) The complex frequency domain signal of the notional signature waveform for each acoustic source is calculated via Fourier Transform, and multiplied by the corresponding transfer function from Step 2) to obtain the frequency domain representation of the received signal from that particular acoustic source;

4) The waveform of the received signal from each acoustic source is reconstructed via Inverse Fourier Transform. The received signal waveforms from all acoustic sources in the array are summed to obtain the overall received signal waveform; and

5) 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 scenarios

Two source locations as shown in **Figure 6** were 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 two selected source locations for the short range modelling

Source Location	Water Depth	Coordinates [Easting, Northing]	Locality
S1	80	[$6.1979*10^6$, $-3.5842*10^6$]	Off the west coast of Cape Egmont
S2	30	[$6.2407*10^6$, $-3.6387*10^6$]	Kupe Field, 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:

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

2) Transmission loss is calculated using RAMGeo at one-third octave band central frequencies from 8 Hz to 1 kHz, with a maximum range of 200 km and at 5 degree azimuth increments. The bathymetry variation along each modelling track is obtained via interpolation from the CANZ (2008) dataset;

3) The one-third octave source SEL levels and transmission loss are combined to obtain the received SEL levels as a function of range, depth and frequency; and

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

3.2.2.2 Modelling scenarios

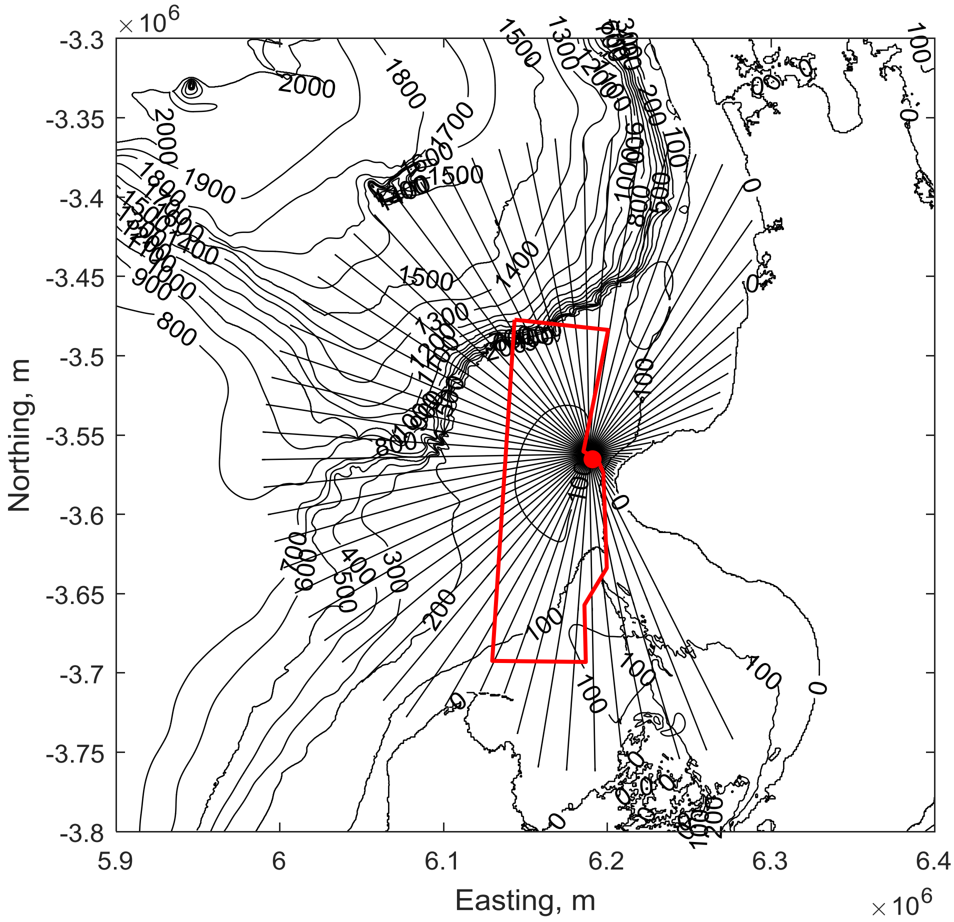
A single source location (L1 as shown in **Figure 6**) with close proximity to the adjacent marine mammal sanctuary is selected for the long range modelling. Details of the selected source location are listed in **Table 4**. The summer season sound speed profile, along with the fine sand seafloor geoacoustic model (i.e. the predominant sediment type along the long range propagation path from the source location to the coastal marine mammal sanctuary) have been used for the long range modelling as a worst case scenario.

The draft map for the proposed Operational Area provided by the client indicates that the survey line around the modelling location will be approximately 80^o anti-clockwise from 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 [Easting, Northing]	Locality
L1	109	[6.189×10^6, -3.562×10^6]	Closest northeast boundary location of the Operational Area to the adjacent marine mammal sanctuary area

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 two source modelling locations (S1 and S2) with the summer season sound speed profile and the fine sand seabed sediment have been calculated. The maximum received SELs across the water column for the two modelling source locations are presented as a function of azimuth and range from the centre of the array in **Figure 12**. Both locations illustrate higher SELs in both the in-line and cross-line directions as a result of the directivity of the source array.

The scatter plots of the predicted maximum SELs across the water column from the source array for all azimuths are displayed in **Figure 13** for the two source locations, 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). For both source locations the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1.5 km. However, the modelling results have shown that the SELs are above 171 dB re 1µPa^2·s at 1.0 km at both locations.

The predictions of the maximum SELs received at the three mitigation ranges for the two short range modelling locations are listed in **Table 5**. **Table 6** presents the ranges from the centre of the source array to where the predicted maximum SELs meet the threshold levels (186 dB and 171 dB re 1µPa^2·s) for the two modelling scenarios.

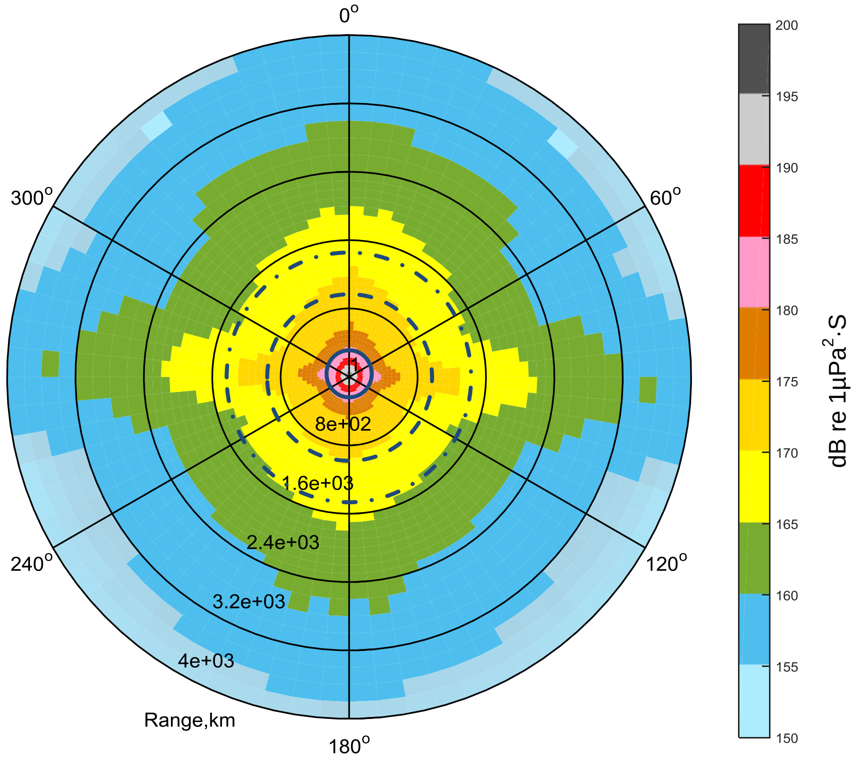
Table 5 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the Boltgun 5,085 cubic inch array for the two source locations S1 and S2.

Source location	Water depth, m	Seafloor	SEL at different ranges, dB re 1µPa^2·s		
			200 m	1.0 km	1.5 km
S1	80	Fine sand	185.5	171.6	168.3
S2	30		184.8	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 two source locations S1 and S2.

Source location	Water depth, m	Seafloor	Ranges complying with the following SEL thresholds, m	
			SEL < 186 dB re 1µPa^2·s	SEL < 171 dB re 1µPa^2·s
S1	80	Fine sand	190 m	1,100 m
S2	30		178 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 centre of the array. 0 degree azimuth corresponds to the in-line direction. The modelling scenarios are for source location S1 (top) and S2 (bottom) with water depth 80 m and 30 m respectively. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).



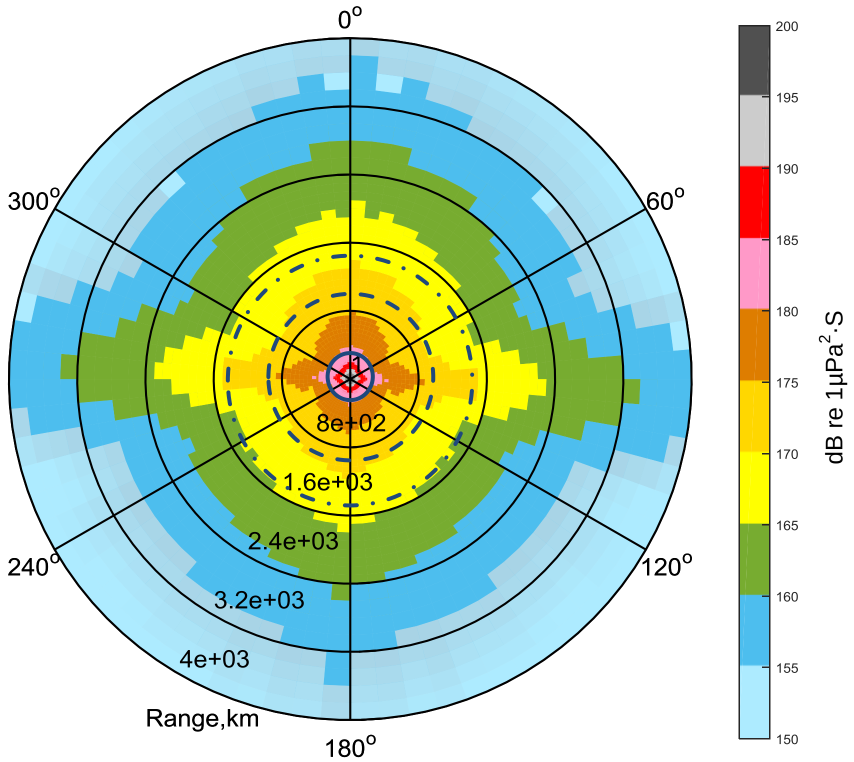
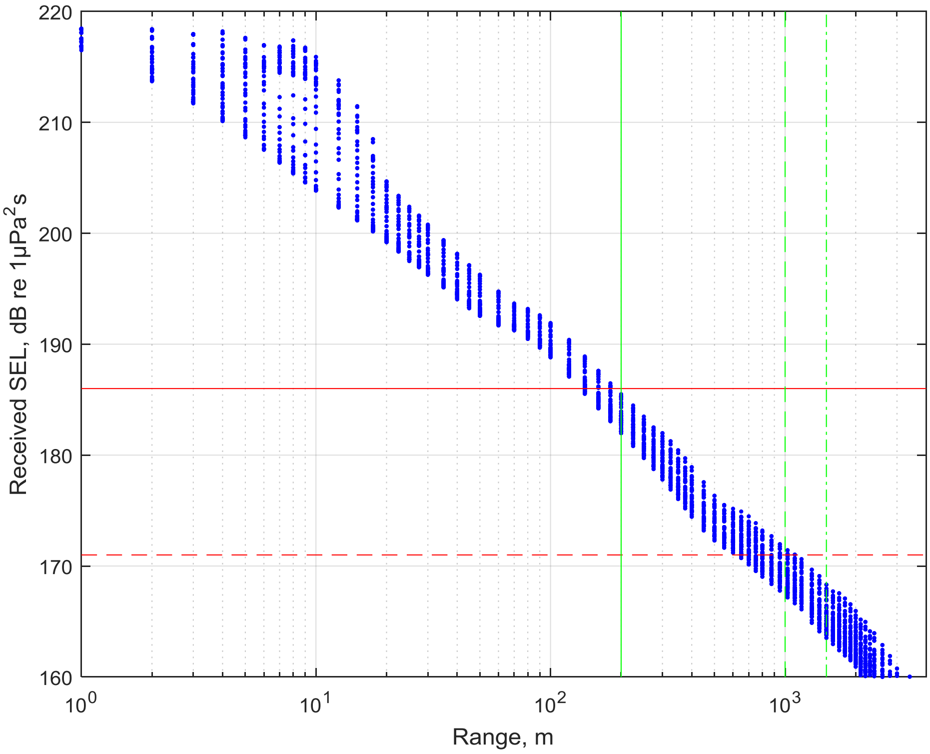
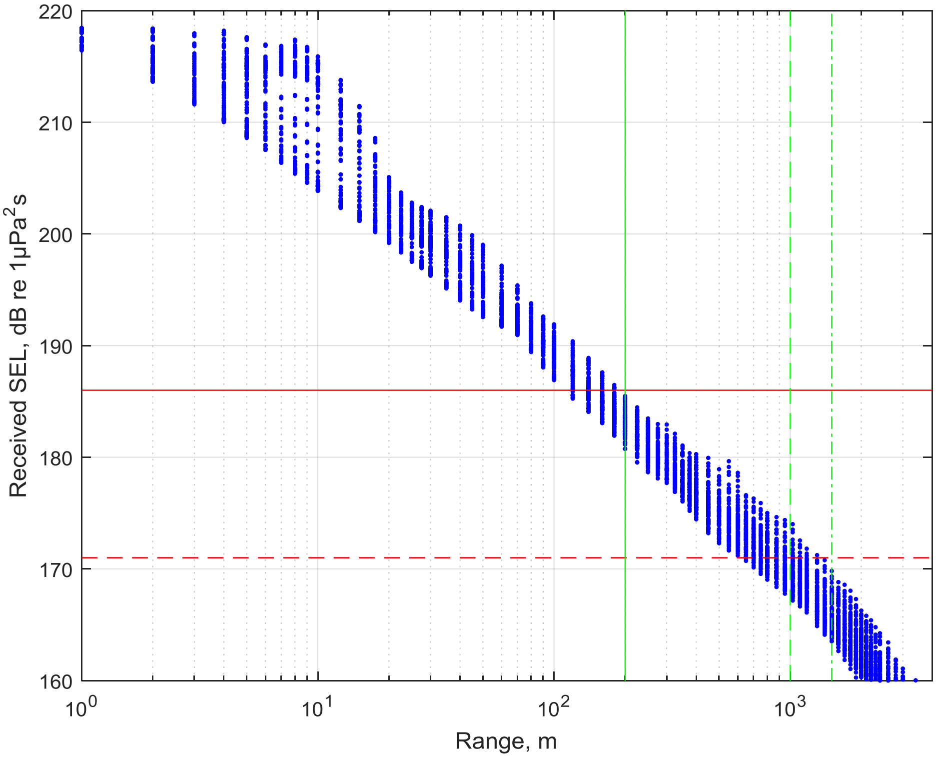


Figure 13 Scatter plots of predicted maximum SELs across the water column from the Boltgun 5,085 cubic inch array for all azimuths as a function of range from the centre of the source array. Source location S1 (top) and Location S2 (bottom) with water depth 80 m and 30 m respectively. Horizontal red 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).

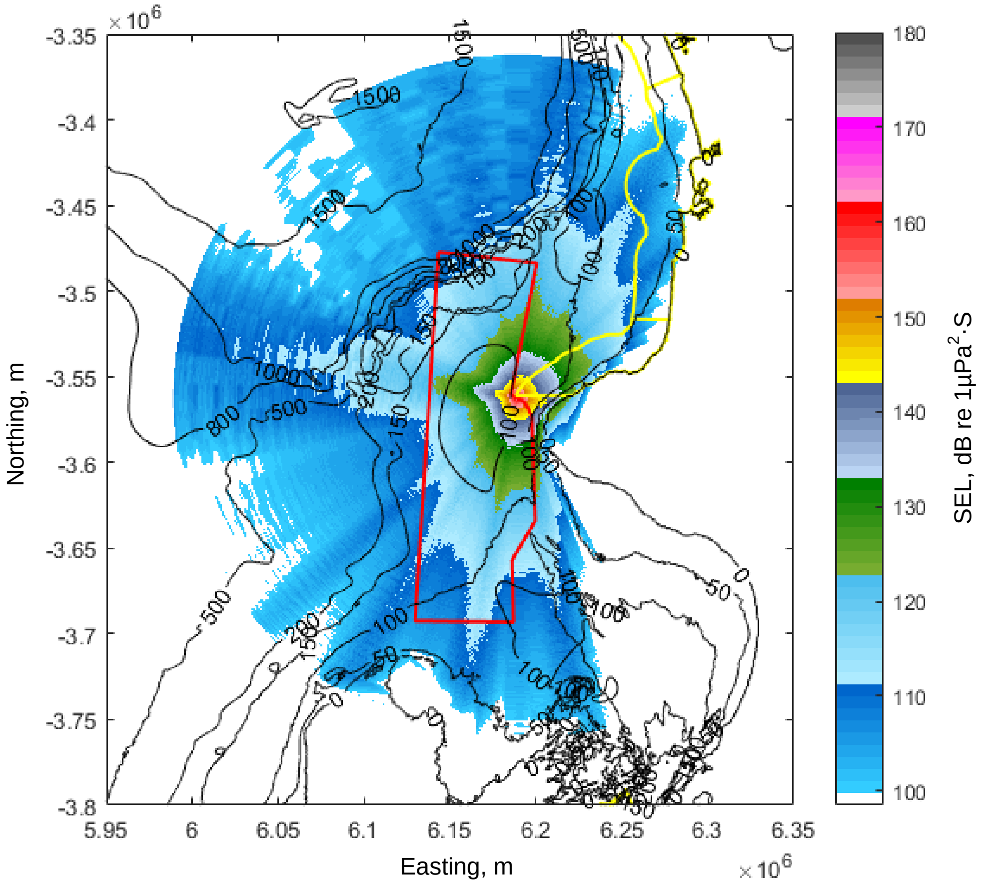




4.1.2 Long range modelling

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 cross-line approximately 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 from the source location L1 in the western direction at a distance of 200 km are predicted to be as high as 110 dB re 1µPa^2·s, which is the highest received SEL at 200 km among all azimuths.

Figure 17 and **Figure 18** present the modelled SELs vs range and depth along the in-line approximately north-south and south-north direction respectively. Relatively constant shallow water depths along the two directions favour 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 southern direction with up-slope bathymetry profiles.

Schlumberger New Zealand Limited

The nearest boundary of the West Coast North Island Marine Mammal Sanctuary is approximately 1.0 km from the source location. The maximum SELs received from the source location L1 at the nearest boundary point are predicted to be up to170 dB re 1µPa^2·s.

Figure 15 Modelled SELs vs range and depth along the propagation path in west-east cross-line direction from the source location. Black line shows the seabed depth variation.

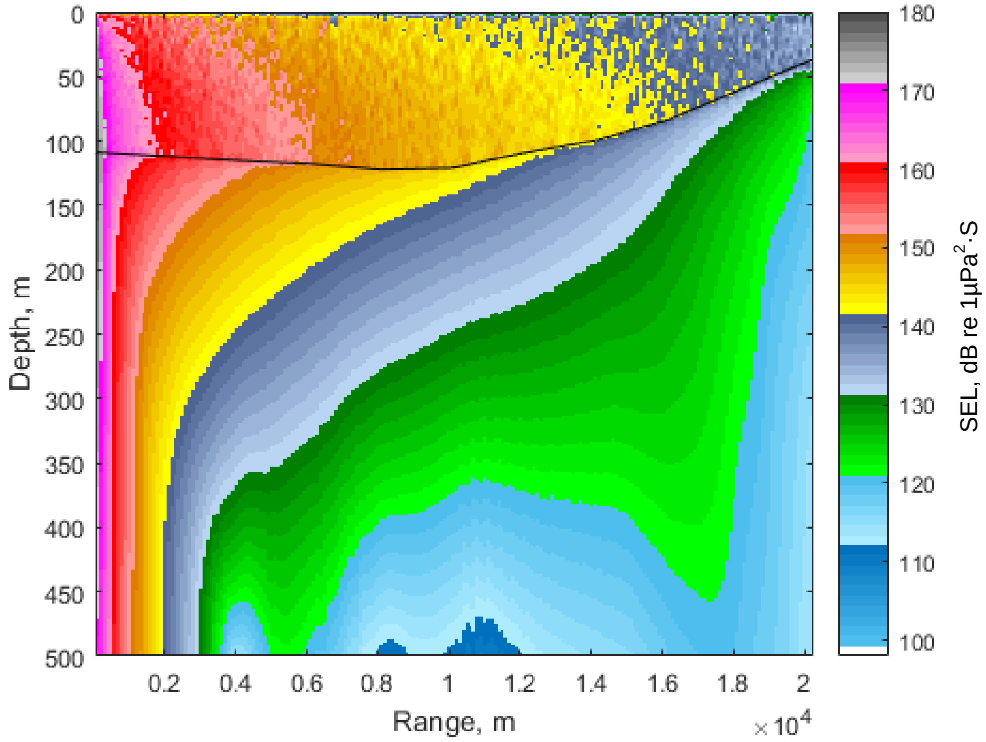


Figure 16 Modelled SELs vs range and depth along the propagation path in east-west cross-line direction from the source location. Black line shows the seabed depth variation.

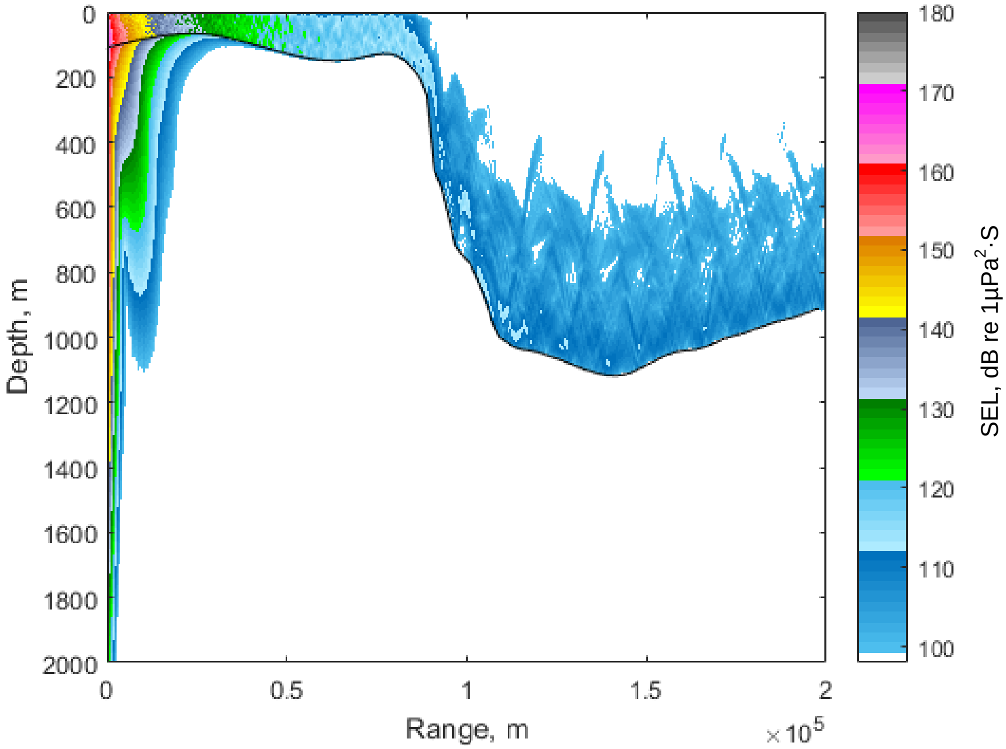


Figure 17 Modelled SELs vs range and depth along the propagation path in north-south inline direction from the source location. Black line shows the seabed depth variation.

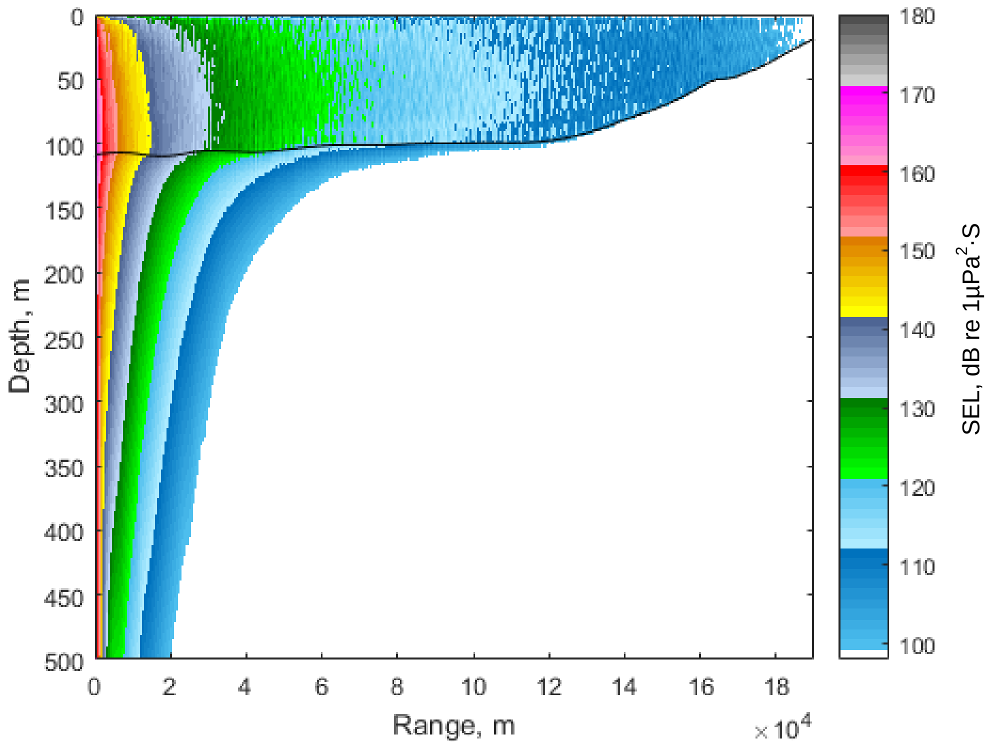
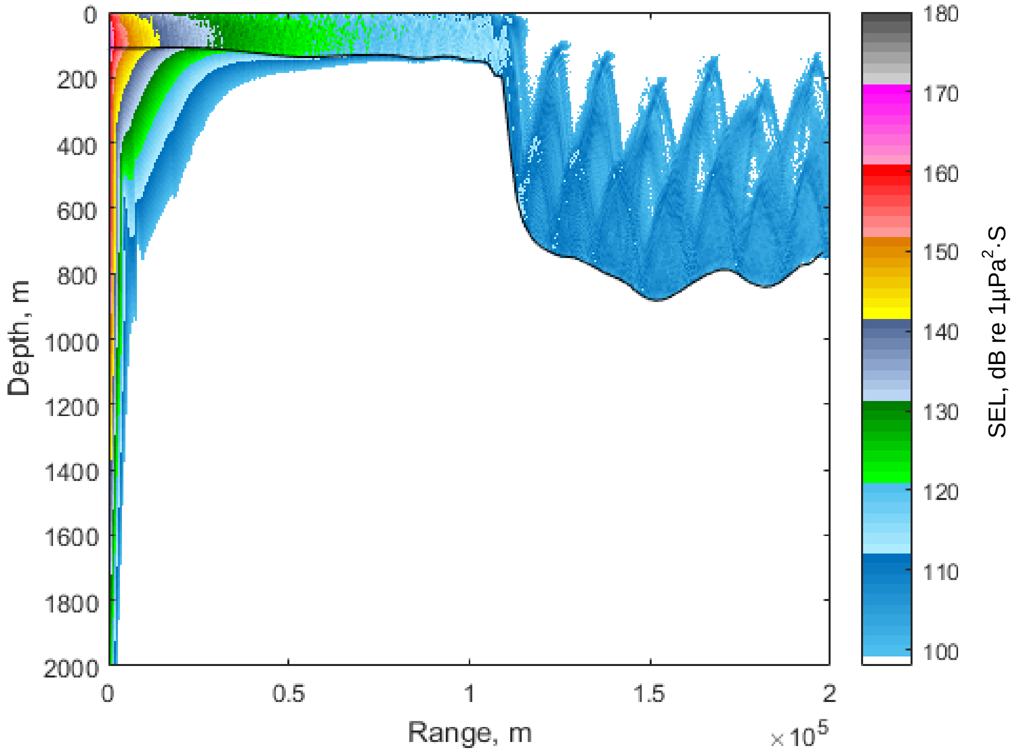


Figure 18 Modelled SELs vs range and depth along the propagation path in south-north inline direction from the source location. Black line shows the seabed depth variation.



5 CONCLUSIONS

SLB is proposing to acquire a three dimensional (3D) multi-client marine seismic survey in the Taranaki Basin in the fourth quarter of 2017. This report details the STLM study that has been carried out for the proposed survey, which includes three modelling components - array source modelling, short range modelling and long range modelling. The 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 two selected source locations. However, at both modelling locations, maximum received SELs are 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 source location L1 in the western direction at a distance of 200 km are predicted to be as high as 110 dB re 1µPa^2·s, which is the highest received SEL at 200 km among all azimuths. The West Coast North Island Marine Mammal Sanctuary has a minimum distance of approximately 1.0 km to the chosen long-range modelling source location. The maximum SELs received from this source location at the sanctuary boundary are predicted to be up to 170 dB re 1µPa^2·s.

6 REFERENCES

Antonov, J. I., Seidov, D., Boyer, T. P., Locarnini, R. A., Mishonov, A. V., Garcia, H. E., Baranova, O. K., Zweng, M. M., and Johnson, D. R., 2010, *World Ocean Atlas 2009, Volume 2: Salinity.* S. Levitus, Ed. NOAA Atlas NESDIS 69, U.S. Government Printing Office, Washington, D.C., 184 pp.

CANZ, 2008, New Zealand Region Bathymetry, 1:4 000 000, 2nd Edition, *NIWA Chart*, Miscellaneous Series No. 85.

Collins, M. D., 1993, A split-step Padé solution for the parabolic equation method, *J. Acoust. Soc. Am.*, 93: 1736-1742.

Del Grosso, V. A., 1974, New equation for the speed of sound in natural waters (with comparisons to other equations), *J. Acoust. Soc. Am*. 56: 1084-1091.

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.

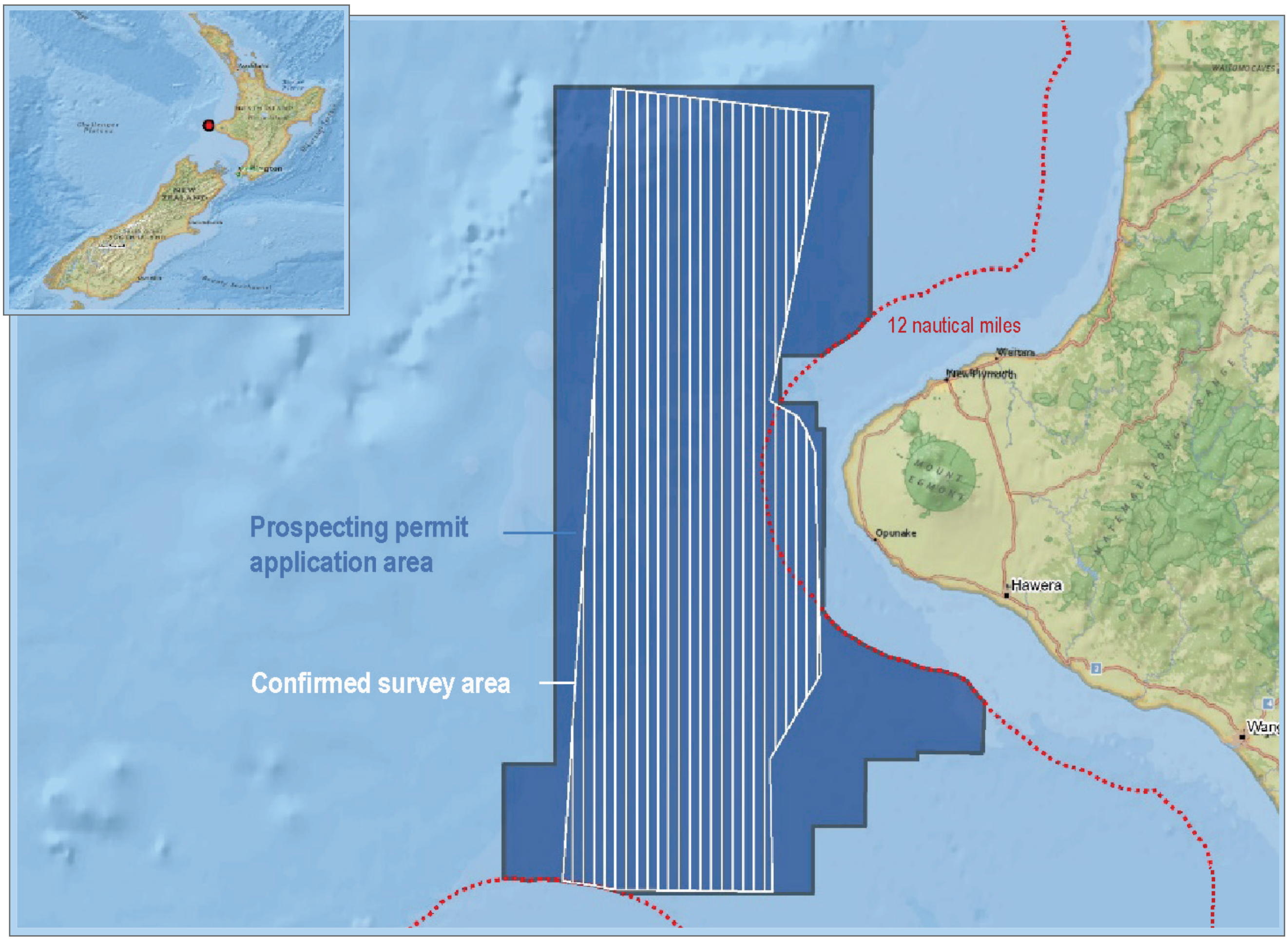
ACOUSTIC TERMINOLOGY

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

Information Sheet

Western Platform Geophysical Survey

Information for the local community



Schlumberger New Zealand (SNZL) will be conducting a geophysical survey in the Taranaki basin off the west coast of New Zealand's North Island. The survey will be carried out by WesternGeco, the seismic business of Schlumberger, to gather geological information on potential oil and gas reservoirs. The survey will be conducted under a prospecting permit from New Zealand Petroleum and Minerals.

A WesternGeco purpose-built seismic vessel will collect data over an offshore area of about 6,000 km² generally from Mokau south to Whanganui. The project is expected to begin in December 2017 and continue for about three months, depending on weather.

A WesternGeco crew will operate the geophysical equipment onboard the survey vessel, while a New Zealand marine crew will be onboard the survey, support and scout vessels. The project plays an important role in the New Zealand government's plan to create jobs and growth through unlocking the area's petroleum potential, and follows close consultation with the New Zealand government, iwi and local communities.

Environmental responsibility

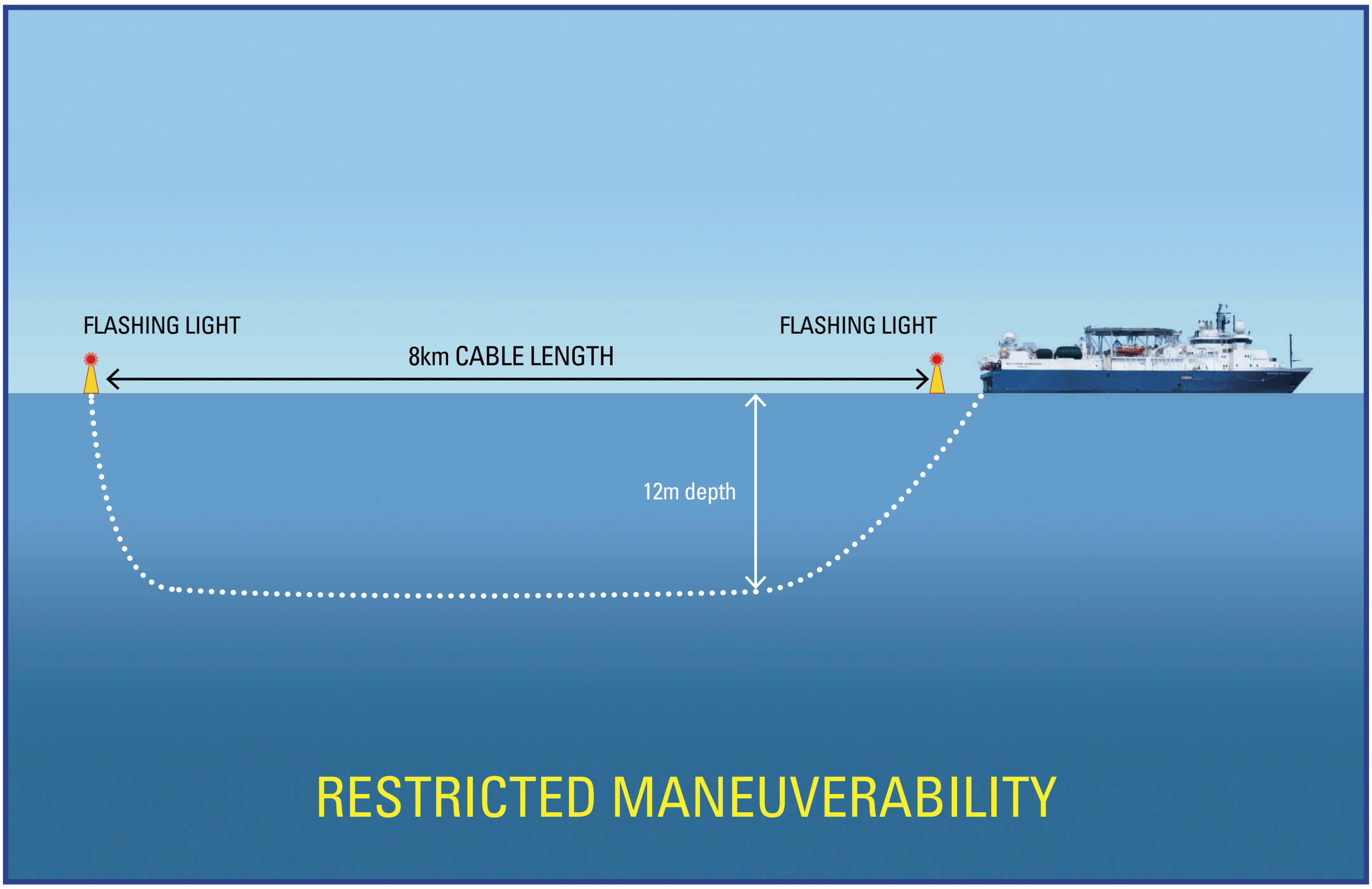
Schlumberger understands its environmental responsibilities and is an industry leader in conducting safe geophysical operations in environmentally sensitive areas. An environmental impact assessment is being conducted to ensure the protection of marine life, and all seismic activity will adhere to the Department of Conservation's strict Code of Conduct for minimizing acoustic disturbance to marine mammals.

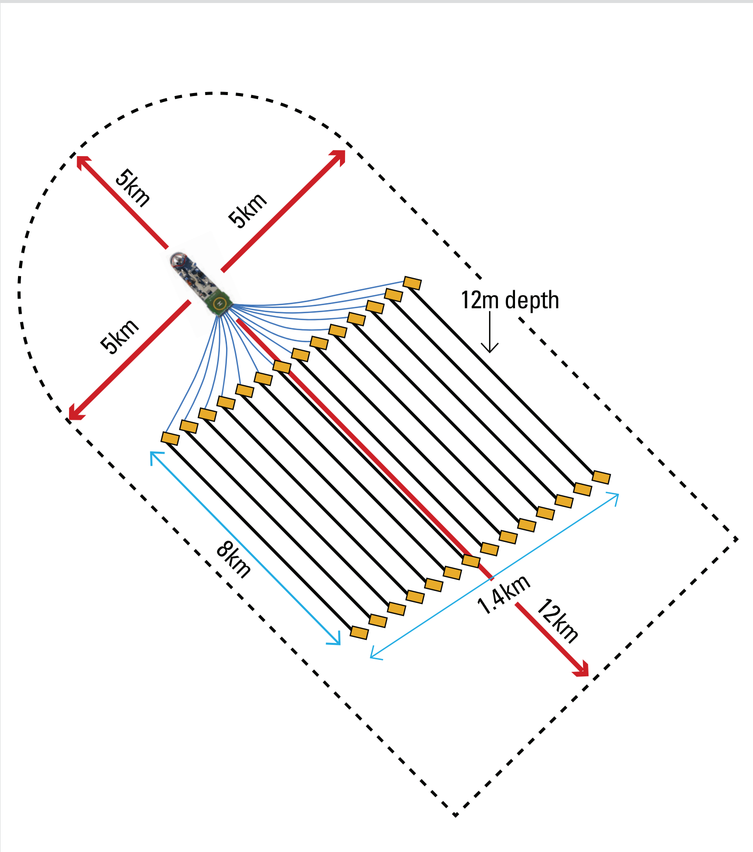
Passive Acoustic Monitoring will be undertaken 24 hours a day during operations to detect the presence of marine mammals. Two independent trained Marine Mammal Observers and two Passive Acoustic Monitoring system operators will be onboard at all times.

In addition, Schlumberger intends to provide sea time for iwi trainees to facilitate qualification on Passive Acoustic Monitoring / Marine Mammal Observation for their future employment opportunities. These trainees will join the qualified observers onboard the vessel as part of their training and to increase visual observations during the survey.

For more information, please contact
Schlumberger Multiclient
environmentNZ@slb.com

Survey Parameters





NOTICE TO FISHERMEN:

Schlumberger will be conducting a geo-physical survey in the Taranaki basin off the west coast of North Island from December 2017 - February 2018 (expected completion). A purpose-built seismic vessel will conduct the survey, towing 14 cables, 8 km long and 12m below the water surface.

The cables contain electronics and can damage fishing gear if crossed. The boat is slow-moving (less than 5 knots) and has restricted maneuverability, so please give her a wide berth. Stay clear at least **12km astern, 5km abeam** and **5km ahead**. VHF operating channel will be 74 with constant monitoring on channel 16.

Engagement Register

<table>
<tr><th>Stakeholder</th><th>Means</th><th>Date</th><th>Feedback</th></tr>
<tr><td>Te Atiawa Trust</td><td>Meeting</td><td>2.10.17</td><td rowspan="2">A combined meetin was held between Te Atiawa Trust and Ngati Rahiri hapu o Te Atiawa.
Concerns were raised to ensure that the survey vessel would not operate within the Marine Mammal Sanctuary. Survey lines will be provided on a map to show that the survey lines are well away from the boundary of the sanctuary.
A request was made to review the MMIA prior to submission to DOC and for a final version following regulatory approval.

Following the meeting a summary was provided to Schlumberger outlining:
• A list of trained and qualified Iwi MMO and PAM operators in Taranaki and support for these folk to be utilised during the survey
• There is the potential risk for lack of support for iwi PAM operators during the survey
• Concern over declining pay rates for iwi MMOs & PAMOs
• Provider preference from previous experience
• The requirement for the ship to be blessed prior to the survey
• Requesting daytime operations only near the West Coast North Island Marine Mammal Sanctuary – further analysis of the survey line plot showed this to be unnecessary (closest line is 8.5 km from the sanctuary)
• Requesting daytime operations in a proposed wāhi tapu site in the STB for blue whales (coordinates to be provided)
• Acceptance of SLBs offer for post-survey bathymetry information</td></tr>
<tr><td>Ngati Rahiri hapū o Te Atiawa</td><td>Meeting</td><td>2.10.17</td></tr>
<tr><td>Otaraua Hapu</td><td>Meeting</td><td>2.10.17</td><td>Unfortunately this meeting was cancelled the day of meeting; however, Otarauau Hapu are in agreement with what concerns and recommendations Ngati Rahiri provided.</td></tr>
<tr><td>Manukorihi Hapu</td><td>Meeting</td><td>2.10.17</td><td>It was expressed that iwi presentations following last years seismic survey was very valuable to the community and schools in the region. Would like to see this continue following the Schlumberger survey.
Similar to Otaraua Hapu, Manukorihi are happy to let Ngati Rahiri take the lead given the experience they have with the seismic industry.</td></tr>
<tr><td>Ngati Mutunga</td><td>Meeting</td><td>2.10.17</td><td>Ngati Mutunga had met with Ngati Rahiri prior to meeting, and endorsed all comments provided by Ngati Rahiri. They would like their people that are trained to be used as MMOs during the survey.</td></tr>
</table>

			The iwi is willing to facilitate the BOSIET training and medicals to ensure the MMOs are competent and able to head offshore. Request was made to receive a copy of the MMIA once approved.
New Plymouth Sport fishing & Underwater Club	Meeting	2.10.17	It was preferable to the club if the survey started on the inshore component of the survey, working offshore to minimise conflict with the game fishers. The most important area is along the 100 m contour line and this appears to be largely inside of the Operational Area. The gamefishing season generally starts in second-third week of February and the first gamefishing competition starts in February 2018. The 48 hour look ahed plan for the survey opreations will be provided during the competitions so that everyone knows where everyone else as a way of minimising conflict. The sportfishing club has 1500 members so any information can be easilyt distributed via email or social media to ensure there is widespread awareness of the upcoming survey.
Nga Ruahine	Meeting	3.10.17	A request was made to receive a copy of the MMIA and MMO report following completion and regulatory approval. It was also requested that it would be very beneficial to see a large hui held at the end of the survey will all of the iwi groups. It was noted that this is not common practice though by Nga Ruahine. Survey details will be passed on to Nga Ruahine Fisheries.
Department of Conservation – Taranaki	Meeting	3.10.17	An overview was provided on the Maui dolphin monitoring programme for the upcoming year. A number of C-Pods have been deployed to liste for any Maui’s dolphins. It was requeste that the vessel will provide immediate notification of any Maui’s/Hector’s sightings. Request marine mammal sighting data also collected ‘off-survey’ Confirmed that there are no blue whale surveys this coming summer, but there are hydrophones deployed in the STB. Schlumberger’s commitment to necropsies during the survey was discussed following an assessment of the stranding location in relaton to the survey vessel. DOC Taranaki are going to inform Whanganui DOC and Maniapoto DOC to be aware of this should a stranding occur within their territory.
Egmont Seafoods	Meeting	3.10.17	The areas that are fished around Taranaki were discussed and at what times of the year in relation to the proposed survey. Some of the fishers don’t fish much deeper than the 100 m depth contour and some don’t go beyond 12 nm offshore.

			It was considered that most of the survey area will not be an issue to fishing activities as long as there is good communication with the survey vessel and fishers. Schlumberger are going to provide all the vessels contact details and will provide the fishers with the 48 hour look ahead every 24 hours. It was discussed that cellphone coverage is patchy in some of the areas that the commercial fisher's fish, so best mode of communication is either Channel 67 or 61.
Taranaki Regional Council	Meeting	3.10.17	Discussed the numerous Taranaki applications under the Marine and Coastal Area (Takutai Moana) Act 2011 There were no concerns from the TRC about the survey but made it clear if there were any non-compliances the TRC want to know about it immediately – whether inside or outside CMA. Information sheet is to be provided to TRC for distribution if any calls are received requesting information about the survey.
Te Runanga o Ngati Ruanui Trust	Meeting	4.10.17	The general iwi are very sensitive towards exploration activities with the recent sand mining application currently in the High Court. Requested to hear of any non-compliance issues during the survey so the iwi can communicate with their kaumatua. Involvement of iwi MMOs was discussed and it was confirmed that two of the Taranaki trained MMOs have Ngati Ruanui affiliation. They would like to receive a copy of the MMIA and MMO report once complete. Ngati Ruanui would like to be notified of when the vessel is going to commence and will be provided with the information sheet for distribution.
Te Kaahui o Rauru	Meeting	4.10.17	A number of discussions were held around what a seismic survey involves and what the potential effects from a seismic survey might be and mitigation measures that will be in place operating under the Code of Conduct. There was concern raised over the blue whale population in the South Taranaki Bight. Were interested to know what direct benefits to iwi would come from the survey Information sheet is to be provided for distribution among iwi. Provided follow up email stating that the iwi does not support seismic testing in the South Taranaki Bight.
Taranaki Iwi Trust	Meeting	4.10.17	Discussion around the details and timing of the survey was held. The iwi MMOs in Taranaki that could potentially be involved in the survey were discussed. Information sheet will be provided for distribution. Will discuss the survey further with the other iwi chairs at their upcoming Taranaki iwi chairs meeting.

Department of Conservation – National Office	Meeting	5.10.17	Went through the survey timings, modelling results, engagement process and mitigation zones that will be in place. Discussed the ramifications of the new McCauley et al 2017 paper re impacts of seismic on zooplankton, in specific to krill populations in the STB and blue whales. Potential effects on crayfish larvae was discussed and it was advised that for future surveys the crayfishing industry should be engaged with. The EPA will perform an audit of the vessel offshore whilst in operation early in the survey to ensure compliance with the Code of Conduct and MMIA/MMMP. EPA and DOC to receive the weekly MMO reports EPA requested the shapefiles of the Operational Area. Information sheet on the survey once approved for release was to be distributed to DOC and EPA.
Environmental Protection Authority	Meeting	5.10.17	This meeting was combined with DOC – National Office, see notes above.
Commercial Fisheries Nelson	Meeting	5.10.17	Meeting was held and represented Deepwater Group, commercial fishers and southern inshore fishers. The jack mackerel mid water trawl fishery season commences in October, and the survey area makes up a large part of their fishing grounds. Vessels will be in the survey area for the duration of the seismic survey. There will be seven trawlers fishing for mackerel. The vessel managers and vessels will be provided with the 48 hour look ahead report every 24 hours. All the vessels contact details have been incorporated into the concurrent operations document. Good communication between all the vessels will be in place to minimize any conflict. It was discussed that the best way to manage it will be to let the captains manage the operations at sea. Seismic is not new to the region and the vessels have operated around seismic vessels many times in the STB. Was discussed that the surveys will run north-south and each run of the survey will take approximately 24 hours. The fishing industry would like to receive the MMO report after the survey and any oceanographic data gathered such as sea temp and salinity. Information sheet to be provided once approved for release.
Department of Conservation – Takaka	Meeting	6.10.17	Main concern from the survey is the effect on the krill populations in the STB. And what impact any potential influence on the krill population could have to the blue whales in the STB. The current study on blue whales was discussed. Was stated that Oregon State University are modelling sighting data to sea temperature and chlorophyll data to see if there is any correlation between the sightings and

			oceanographic data as a way of predicting where blue whales may be. Post-survey engagement was requested following completion of the survey. And they would also like to see an iwi representative at these meetings as well. It was asked whether Schlumberger are contributing towards any research into effects of seismic on krill. The study that CSIRO are performing was discussed which was commissioned by APPEA of which Schlumberger are a member. It was suggested that it would be good to see a study on krill populations during the Schlumberger survey. The Farewell Spit pilot whale strandings each year were discussed which tend to occur during November to March. DOC and Manawhenua ki Mohua want to be notified prior to the survey vessel arriving, the likely start date of the survey and again when the survey is finished. Information sheet once approved for release will be distributed.
Manawhenua ki Mohua	Meeting	6.10.17	This meeting was held with DOC Takaka, see notes above.
Ngati Tama	Phone call	22.09.17	Declined offer to engage
Ngati Maniapoto	Email	18.09.17	Declined offer to engage
Oregon State University	Email	26.09.17	Advised that the only research activities this summer would be the recovery of the hydrophones in January or February. Requested MMO sightings data for blue whales and any associated photos.
Forest and Bird	Email	5.10.17	Identified concerns for blue whales, and also for data deficient species (e.g. pygmy right whales and Shepherd's beaked whales) stating that it is more difficult to mitigate effects for these species.
NIWA	Email	4.10.17	No response yet
Project Jonah	Email	4.10.17	Was appreciative of the update and asked to view the MMIA which will be provided.
University of Auckland	Email	25.10.17	No response yet
Puketapu Hapu	Email	4.10.17	Are interested in the survey but were not available during New Plymouth visit. Trying to set up a meeting between Schlumberger and the hapu.

Marine Mammal Mitigation Plan

The Western Platform Multi Client 3D Seismic Survey

Marine Mammal Mitigation Plan

Report Number 740.10032.00300

23 November 2017

Schlumberger New Zealand Ltd
94 Paraite Road
New Plymouth 4373

Version: v1.0

The Western Platform Multi Client 3D 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	Status	Date	Prepared	Checked	Authorised
740.10032.00300	v1.0	23 November 2017			
740.10032.00300	V0.2	13 November 2017			

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 'Western Platform Multi Client 3D Seismic Survey'.

This MMMP will be used by observers and crew to guide operations in accordance with the Department of Conservations (DOC) *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* ('Code of Conduct').

1.2 Survey Outline

Schlumberger New Zealand Ltd (Schlumberger) is proposing to acquire a three dimensional (3D) marine seismic survey in the Taranaki Basin. The Operational Area within which all seismic operations will be restricted is illustrated in **Figure 1**. The majority of seismic operations will occur in an area that runs from approximately 100 km offshore of Marokopa in the north to 180 km offshore of Himatangi Beach in the south. In the southern portion of the Operational Area a tie line will extend eastwards towards Patea. Note that the Operational Area extends into the territorial sea off Cape Egmont. 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 1 km to the east of the Operational Area. However, it is noteworthy that the closest acquisition line is 8.5 km west of the sanctuary boundary. Water depths within the Operational Area range from 30 to 1,000 m.

The seismic survey is predicted to take up to three months to complete, and is scheduled to begin on 1 December 2017.

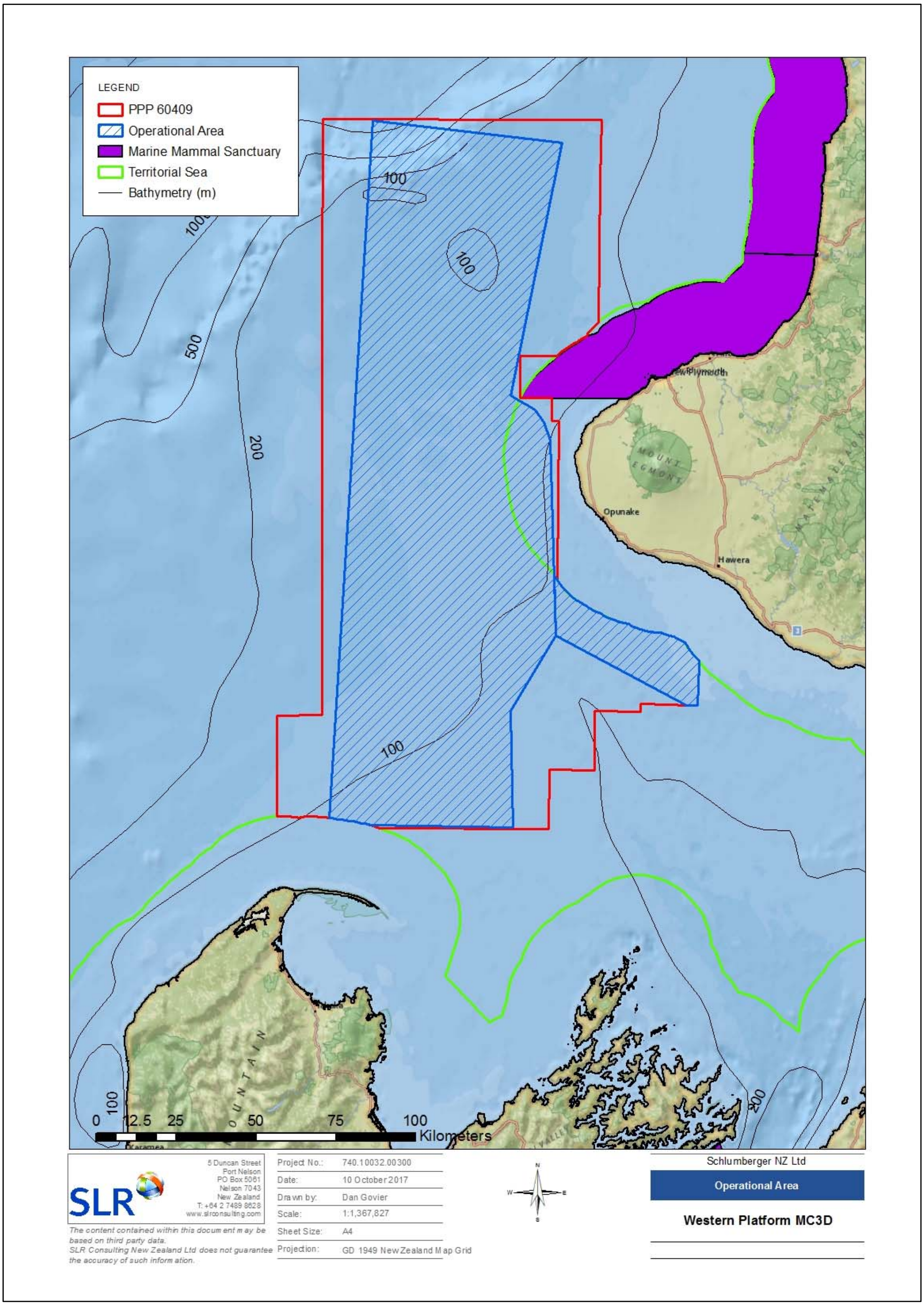
The *M/V Amazon Warrior* will undertake the surveys with an acoustic source volume of 5,085 in^3. The acoustic source will be activated at a source-point interval of 25 m. For a vessel speed of 4.5 knots, this equates to source activation every 10.8 seconds. According to the Code of Conduct, the Western Platform Multi Client 3D 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.

Schlumberger has been involved in a number of seismic projects in the Taranaki Basin over the last few years. Existing seismic data from the proposed Operational Area is insufficient to provide an accurate subsurface image in this geologically complex area; hence the acquisition of modern broadband 3D seismic data, with a high-resolution velocity model is required to make estimates on prospect sizes and structural closures here. The Western Platform Multi Client 3D Seismic Survey will provide a new level of geological understanding in the area and will significantly reduce exploration risk associated with structural uncertainty.

Figure 1 Operational Area for the Western Platform Multi Client 3D 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 Western Platform Multi-Client 3D Seismic Survey.

2.1.1 Notification

The notification requirements of the Code of Conduct have been adhered to. A letter was received by the Director-General of the Department of Conservation on 1 August 2017 notifying DOC of Schlumberger's intentions to carry out seismic surveys 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. The MMIA for the Western Platform Multi-Client 3D Seismic Survey was submitted to DOC on 25 October 2017.

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

Table 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 or email at) to clarify any uncertainty or ambiguity in application of the Code of Conduct.	Communicate with DOC (+64 or email at) 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[1] 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;

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

- 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.

Note that Schlumberger will ensure that 100% redundancy in equipment must be maintained on-board at all times during the Western Platform Multi-Client 3D 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 or email at) 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:
  - 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 (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 Nm of the planned start up position for at least the last two hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than two hours of good sighting conditions preceding proposed operations (within 20 Nm of the planned start up position), the source may be activated if:
  - PAM monitoring has been conducted for two hours immediately preceding proposed operations;
  - Two MMOs have conducted visual monitoring in the two hours immediately preceding proposed operations;
  - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones (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.

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 Western Platform Multi-Client 3D Seismic Survey could exceed the SEL thresholds outlined in the Code of Conduct. For this reason, Schlumberger has adopted a larger mitigation zone for Species of Concern during the Western Platform Multi-Client 3D Seismic Survey 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 Western Platform Multi-Client 3D 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 Western Platform Multi-Client 3D Seismic Survey will 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, Schlumberger will conduct ground-truthing during the survey to verify the results of the STLM. In order to do this, representative data recorded on the seismic streamers during the seismic survey will be used to compare actual sound exposure levels with STLM predictions and to measure the SELs at each mitigation zone boundary.

The undertaking of this ground truthing is the responsibility of the on-board Schlumberger 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 who can be contacted by phone on +64 or email at . 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 can not be reached, DOC's secondary point of contact is (phone +64 , email).

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 Schlumberger for the purpose of the Western Platform Multi-Client 3D 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 Western Platform Multi-Client 3D Seismic Survey.

2.2.1 Mitigation Zones for Delayed Starts and Shutdowns

As the STLM results exceeded the SEL thresholds defined in the Code of Conduct, Schlumberger has adopted a larger mitigation zone for Species of Concern during the Western Platform Multi-Client 3D 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 Western Platform Multi-Client 3D 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 on +64 , with a follow up email sent to ; and
- Weekly MMO reports will be provided to DOC ( ) 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, Schlumberger has committed to provide an opportunity for a trained iwi MMO on-board the seismic vessel during the Western Platform Multi-Client 3D Seismic Survey.

APPENDIX 1: COORDINATES OF OPERATIONAL AREA

Primary Area	
Longitude	**Latitude**
1601506.06	5756659.266
1660826.837	5749749.89
1644690.244	5670727.522
1652490.883	5666310.304
1655038.48	5662269.117
1657127.252	5656742.837
1658816.558	5595483.943
1644757.943	5571895.168
1645413.484	5535522.87
1601067.467	5536157.865
1598993.275	5536686.915
1597977.345	5536814.135
1596538.446	5537179.559
1595211.889	5537345.262
1594412.402	5537548.405
1591630.841	5537894.812
1590622.763	5537893.648
1588603.671	5538405.28
1587827.812	5538501.293
1601506.06	5756659.266

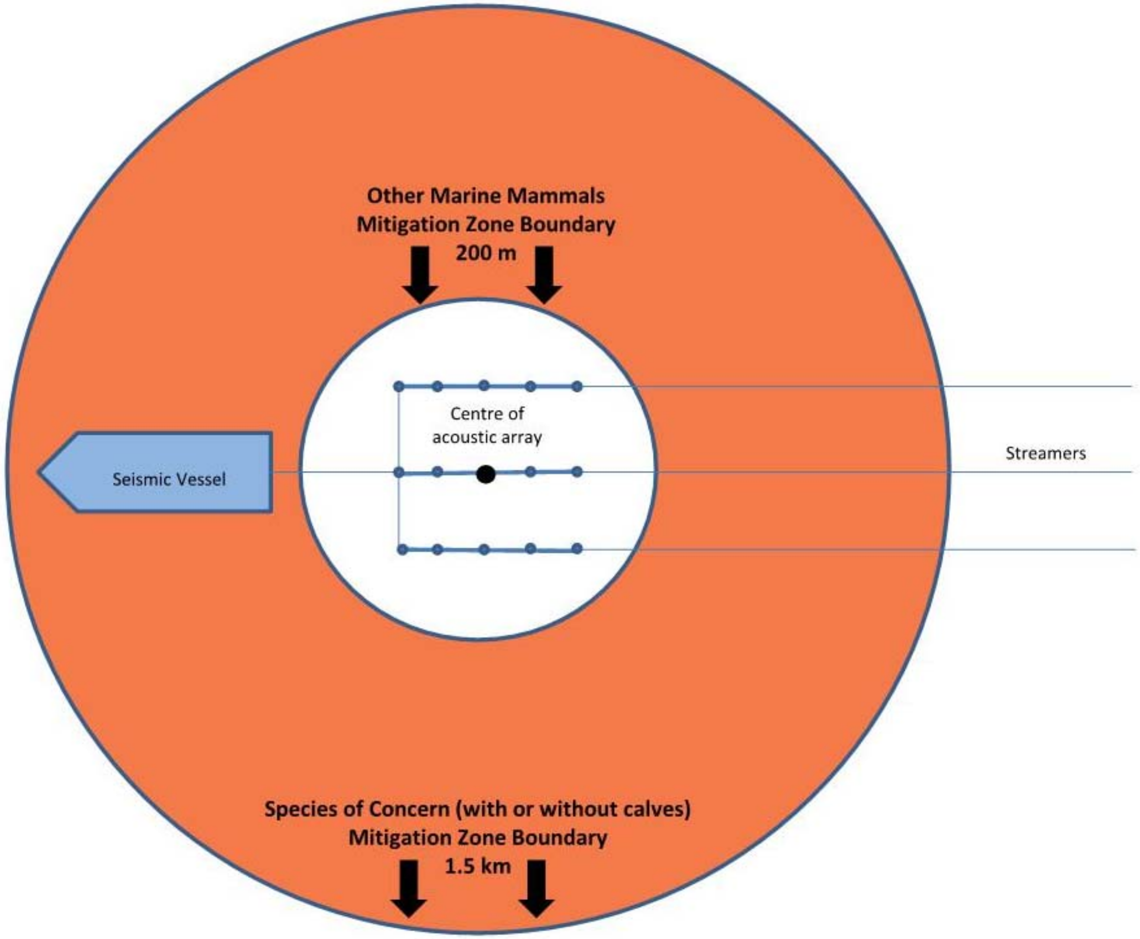
Eastern Extension Area (tie line)	
Longitude	**Latitude**
1658287.212	5614679.487
1658402.601	5614430.075
1659371.39	5612879.536
1659887.552	5612055.692
1661691.917	5609856.431
1663538.532	5608097.217
1663664.617	5607977.098
1665641.908	5606517.189
1665908.114	5606320.657
1667067.588	5605670.767
1668340.516	5604957.429
1668348.189	5604954.056
1669293.94	5604255.132
1670946.724	5603327.979
1671725.397	5602891.166

1673042.06	5602356.042
1674017.143	5601808.451
1675110.394	5601194.493
1677695.179	5600142.423
1679083.692	5599771.056
1680389.447	5599421.82
1681615.728	5599253.927
1682744.125	5598618.99
1684651.106	5597840.355
1685317.982	5597568.19
1688022.06	5596840.551
1690779.883	5596459.776
1691826.978	5596446.664
1692851.994	5596027.115
1695544.46	5595301.24
1696110.452	5595222.6
1696554.044	5594892.968
1698980.439	5593521.057
1699189.059	5593435.432
1700188.596	5591824.552
1701608.527	5590064.967
1702077.463	5589526.598
1703340.978	5588306.042
1703805.511	5587553.384
1703766.028	5585987.945
1703215.341	5573607.2
1699930.075	5573785.136
1658816.519	5595485.356
1658287.212	5614679.487

APPENDIX 2: SPECIES OF CONCERN

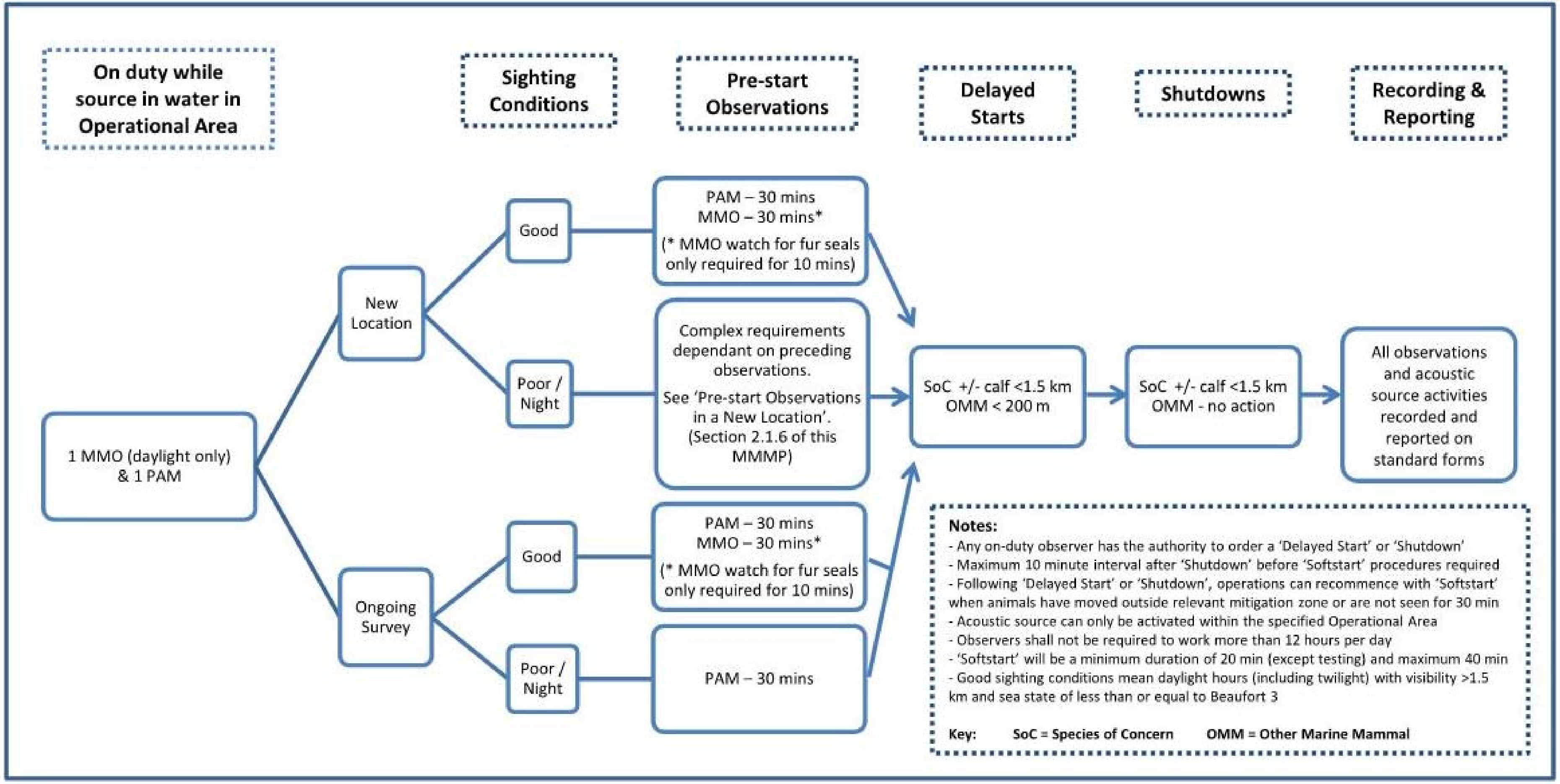
LATIN NAME	COMMON NAME
Megaptera novaengliae	Humpback Whale
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Whale
Balaenoptera bonaerensis	Antarctic Minke Whale
Balaenoptera acutorostrata subsp.	Dwarf Minke Whale
Balaenoptera musculus	Blue Whale
Balaenoptera physalus	Fin Whale
Balaenoptera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

APPENDIX 3: SUMMARY OF MITIGATION ZONES FOR THIS SURVEY



Adapted from the Code of Conduct (DOC, 2013)

APPENDIX 4: OPERATIONAL FLOWCHART



Adapted from the Code of Conduct (DOC, 2013)

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)