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# Nikau 3D Seismic Survey

# Marine Mammal Impact Assessment

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# Nikau 3D Seismic Survey

# Marine Mammal Impact Assessment

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# Executive Summary

OMV New Zealand Ltd (OMV) is proposing to acquire the 'Nikau 3D Seismic Survey' in the Taranaki Basin during November 2016. The Operational Area occurs approximately 25 km offshore in the North Taranaki Bight. The purpose of the survey is to investigate the subsurface geology of the Operational Area to assess its potential for containing oil and gas reserves. The survey will be undertaken by the seismic vessel PGS Apollo using a seismic source array with a total capacity of 3,260 cubic inches. Seismic data will be collected by a span of 10 streamers that contain hydrophones and that extend approximately 8 km behind the seismic vessel.

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

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

A significant part of the development of this MMIA was engagement with stakeholders through the provision of information sheets and meetings.

The marine mammal species that are considered likely to be present in the Operational Area or surrounding waters are Bryde's whales, common dolphins, dusky dolphins, Gray's beaked whales, Maui's dolphins, killer whales, long-finned pilot whales, southern right whale, pygmy sperm whales and sperm whales. Of these species, the following are considered to be threatened by the Department of Conservation's Threat Classification System: Bryde's whales, Maui's dolphins, killer whales and, southern right whales. Both Maui's dolphins and killer whales are classified as 'Nationally Critical' and although they could have a presence, the Operational Area is not considered to be of particular ecological significance for these species (Maui's dolphins are found mostly well inshore of the Operational Area and killer whales are wide ranging and are unlikely to be resident within the Operational Area).

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

# Executive Summary

As the Nikau 3D Seismic Survey will not occur within an 'Area of Ecological Importance', there is no specific requirement under the Code of Conduct for sound transmission loss modelling (STLM) to be conducted. Despite this, OMV opted to conduct STLM as part of the development of this MMIA at any rate; as a means of recognising the ecological values directly inshore of the Operational Area. This modelling was used to predict how far sound from the seismic survey is predicted to travel underwater. Model results indicate the distance from the acoustic source at which marine mammals will be sufficiently protected from behavioural and physiological effects associated with underwater noise. The results indicated that the predicted sound levels will not be compliant with all of the thresholds stipulated in the Code of Conduct for behavioural effects; hence one of the mitigation zones has been extended to account for this. Ground-truthing of the STLM results will also occur during the survey.

In addition to compliance with the Code of Conduct OMV has committed to the following actions to avoid, remedy or mitigate potential adverse effects of the Nikau 3D Seismic Survey on the biological, social, cultural and commercial environment of the geographical region:

- Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey;
- All seismic operations will occur outside 12 nm, hence effects on coastal species (e.g. Maui's dolphins) will be minimised;
- Mitigation zones have been extended to ensure the appropriate protection levels are afforded to marine mammals. A mitigation zone of 1,500 m will be adopted for all 'Species of Concern' (with or without calves);
- Marine mammal sightings will be collected whilst on transit to and from the Operational Area to the local port;
- MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea;
- MMOs to notify DOC immediately of any Maui's dolphin, southern right whale or humpback whale sightings;
- Weekly MMO reports to be provided to the regulators; and
- OMV will consider covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings.

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

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## ABBREVIATIONS AND DEFINITIONS

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

# 1 INTRODUCTION

## 1.1 Background

OMV New Zealand Ltd (OMV) 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** and occurs in the Exclusive Economic Zone of the North Taranaki Bight (approximately 25 km offshore). This survey is referred to as the 'Nikau 3D Seismic Survey'.

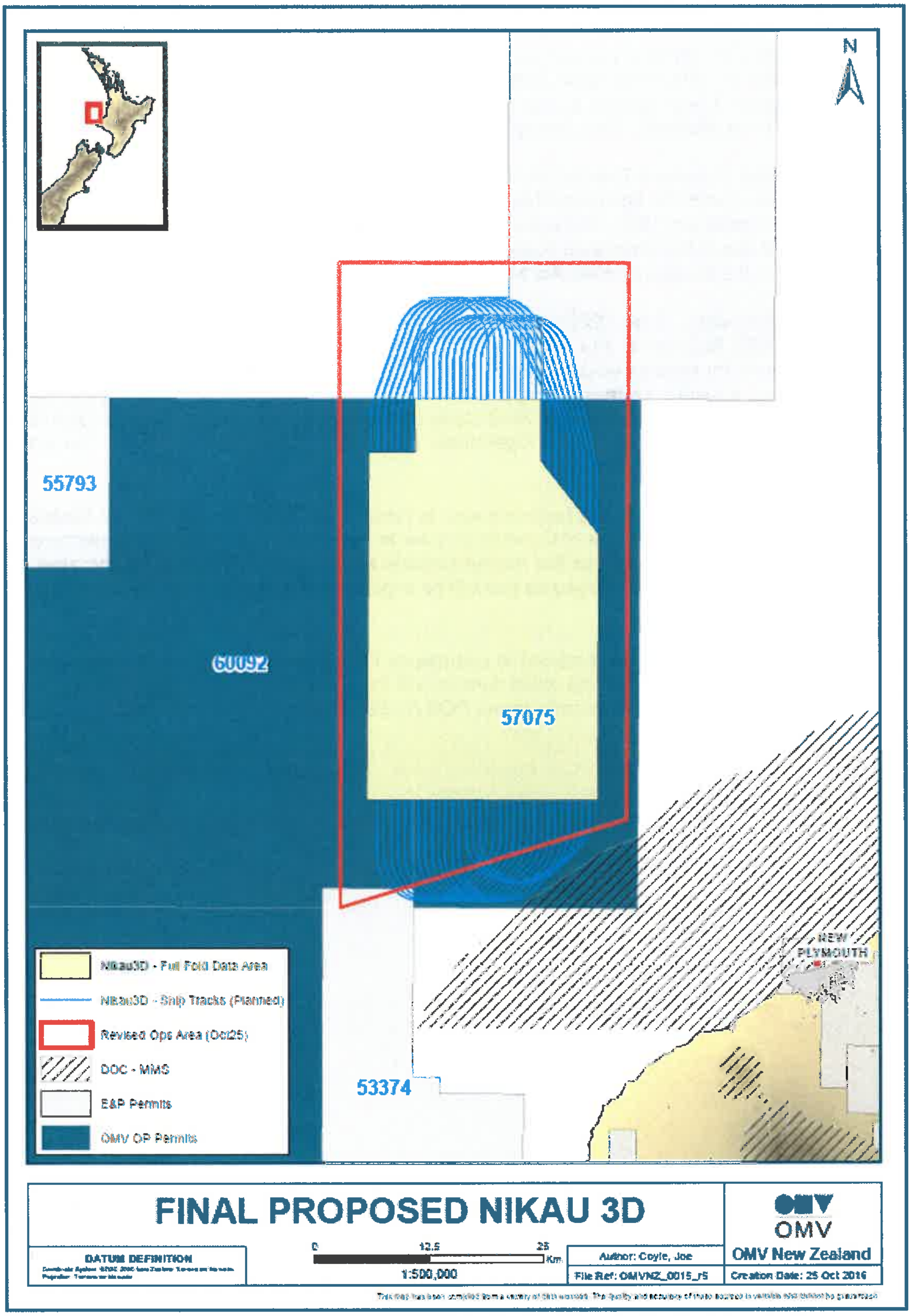
OMV were awarded Petroleum Exploration Permit (PEP 57075 & 60092) by New Zealand Petroleum and Minerals which covers the Operational Area and facilitates the exploration activities. Under Section 23 of the Crown Minerals Act 1991, the purpose of a PEP is to authorise the holder to undertake activities for the purpose of identifying petroleum deposits through geological or geophysical surveying. Further details in regard to the Crown Minerals Act are provided in **Section 3.1**.

The 'Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects – Permitted Activities) Act' (EEZ Act) came into effect in June 2013. The EEZ Act managed the previously unregulated potential for adverse environmental effects of activities within the EEZ and continental shelf. Under the EEZ Act, a marine seismic survey is classified as a permitted activity, providing the operator undertaking the survey complies with the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations' (Code of Conduct) (DOC, 2013). The Code of Conduct is summarised in **Section 3.4**.

SLR Consulting NZ 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 Nikau 3D Seismic Survey on the marine habitats and species in the surrounding area. The MMIA also sets out the mitigation measures that will be implemented to avoid or minimise any potential environmental effects.

The Nikau 3D Seismic Survey is scheduled to commence in November 2016, with an estimated total duration of up to 30 days. However, the exact duration will be dependent on down-time for weather and marine mammal encounters. The seismic vessel *PGS Apollo* will undertake the surveys.

**Figure 1: Location Map of the Nikau 3D Seismic Survey Operational Area**



## 1.2 General Approach

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

The Nikau 3D Seismic Survey is classified as a 'Level 1 Survey' by the Code of Conduct and OMV will comply with the relevant requirements while conducting their survey. The Code of Conduct requirements of a Level 1 seismic survey are outlined in **Section 3.4**, and **Section 6** summarises all the measures that OMV proposes to minimise their environmental effects.

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

## 1.3 Consultation

Existing interests, stakeholders and tangata whenua groups with whom consultation would take place were identified in conjunction with DOC. The resulting consultation process involved either face to face contact or email correspondence. All consulted groups are listed in **Table 1.**

**Table 1: Groups with which consultation has occurred**

| **Iwi** | |
|---|---|
| Ngati Maniapoto | Te Atiawa (Taranaki), Ngati Rahiri Hapu |
| Ngati Tama | Te Atiawa (Taranaki), Manukorihi Hapu |
| Ngati Mutunga | Te Atiawa (Taranaki), OtarauaHapu |
| Taranaki iwi | |
| **Other** | |
| Department of Conservation – Taranaki | Egmont Seafoods |
| Department of Conservation - Wellington | Deepwater Group |
| Environmental Protection Authority | New Plymouth Sport Fishing Club |
| Taranaki Regional Council | Port Taranaki |
| Sanford Fisheries | Talley's Fisheries |
| NIWA | Project Jonah |
| Oregon State University | |

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

The primary commitments made by OMV during the consultation period are summarised here:

- DOC indicated that they were interested in immediate notification of any sightings of southern right whales, humpback whales and Maui's dolphins, particularly if sightings occurred within the 12 Nm Territorial Sea. OMV has agreed to this request; all sightings of southern right whales, humpback whales and Maui's dolphins are to be immediately reported to DOC.
- Provision of information sheet, vessel details, and final MMO report to stakeholders as requested.

## 1.4 Research

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

The principal contribution to research that will be made by OMV is the provision of the Marine Mammal Observer (MMO) report to DOC in accordance with the Code of Conduct. This report includes all marine mammal observation data collected, including where shut downs for marine mammals occurred. The data included in this report will be incorporated into the national marine mammal sighting database and made accessible to third parties for research purposes on request; hence, contributing to baseline knowledge of marine mammals in the Operational Area.

New Zealand is a hotspot for marine mammal strandings. Since 1840, more than 5,000 strandings of whales and dolphins have been recorded around the New Zealand coast. During any stranding event, DOC is responsible for all aspects of stranding management: including whether or not a necropsy will be undertaken to investigate the cause of death. Despite no convincing causal evidence that whale strandings are linked to seismic surveys, marine mammal strandings in the vicinity of seismic surveys often come under the spotlight (Castellote & Llorens, 2016). For this reason stranded individuals in the vicinity of seismic surveys are often targeted for necropsy to investigate potential acoustic injury. OMV will consider covering the costs associated with a necropsy if a dead marine mammal is found inshore of the Operational Area during acquisition and within two weeks of the end of the Nikau 3D Seismic Survey. Any resultant necropsy data would also be of benefit to the research community.

# 2 PROJECT DESCRIPTION

## 2.1 Marine Seismic Surveys - overview

Seismic surveys use the acoustic properties of the earth's crust to infer information on its geological structure. To do so, seismic vessels tow an acoustic source behind the survey vessel within the Operational Area. This source releases compressed air at regular intervals thus creating a directionally focused low frequency sound wave which travels several kilometres through the earth. As the acoustic wave travels through the earth's crust, portions of it will be reflected back towards the water surface by layers of rock. These reflected waves will be recorded by towed hydrophones located in the 'streamers'. The time between the generated and received sound waves enables geologists to calculate the depths of geological strata and to map their spatial extent.

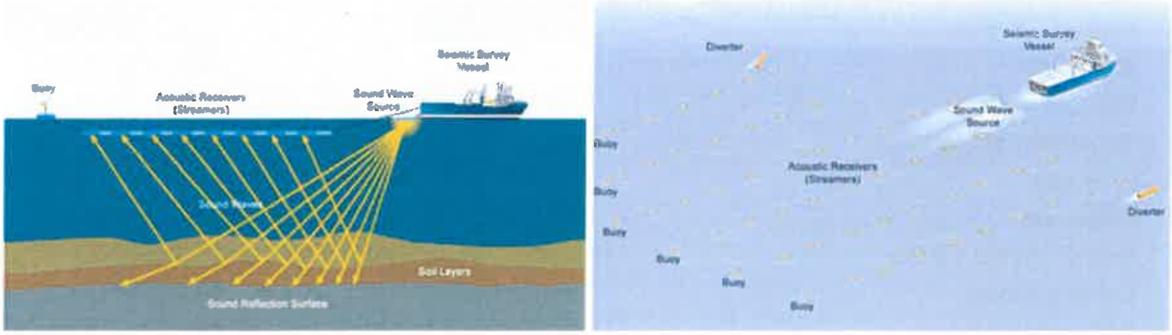
### 2.1.1 2D and 3D surveys

There are two main types of marine seismic survey. These are known as 2-Dimensional (2D) and 3-Dimensional (3D) surveys. A 2D survey is the simpler of the two methods and involves a single source and a single streamer (**Figure 2**). In contrast, a 3D survey involves more sophisticated equipment and many more streamers.

2D surveys tend to be relied on for frontier exploration in areas where a broad understanding of geology is yet to be acquired. Once a 2D survey has been conducted in an area, geological targets which are likely to contain hydrocarbons can be identified. Precise 3D survey techniques using fine-tuned acoustic parameters can then be used to comprehensively examine these target areas and produce a three-dimensional image of the subsurface.

For 3D surveys such as the Nikau 3D Seismic Survey, the seismic vessel tows the acoustic array and up to 10 streamers of hydrophones (at separations of 150 m) (**Figure 2**).

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



(Source: www.fishsafe.eu)

### 2.1.2 Underwater sound

Underwater sound has two primary measures:

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

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

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

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

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

**Table 2: Sound Comparisons in Air and Water**

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

### 2.1.3 The acoustic source

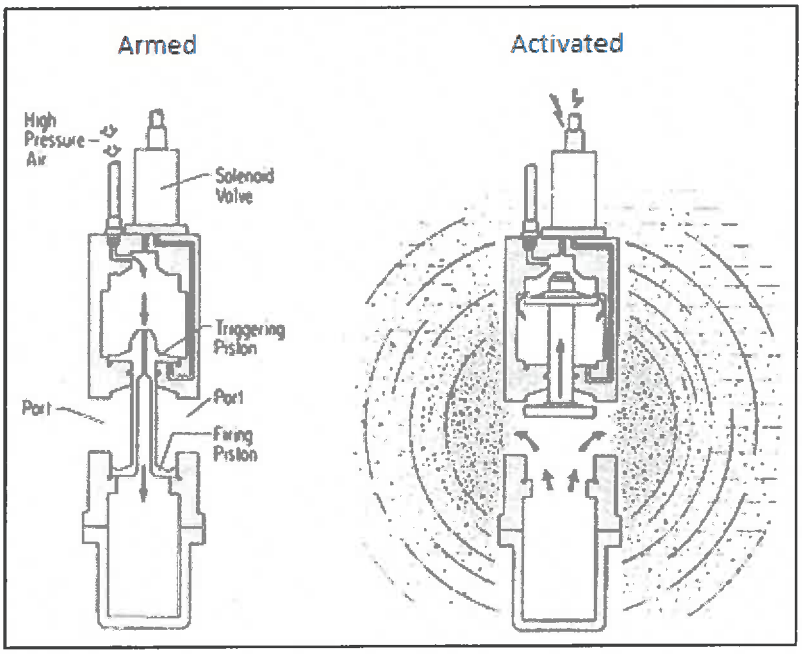
The acoustic source is towed behind the seismic vessel, typically as two arrays which each have a varying number of independent elements. Each element is comprised of high pressure chambers; an upper control chamber and a discharge chamber. High pressure air (~2,000 psi) from compressors on-board the 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 (**Figure 3**).

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

The acoustic arrays involved in seismic surveys are designed to direct acoustic energy vertically towards the seafloor. Negligible amounts of energy will dissipate horizontally into surrounding waters. The acoustic signal will decrease with distance from the source. This is known as attenuation and is frequency dependent (i.e. increased at higher frequencies) and influenced by local conditions (water temperature, depth, seabed characteristics).

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

**Figure 3: Schematic of a typical acoustic element in a seismic array**



### 2.1.4 The streamers

When the source is activated, the hydrophones located in the streamers will record the portion of the emitted acoustic signal which is reflected back up towards the sea surface by the geological structures in the seabed. This acoustic signal is converted into electrical energy which is digitised and transmitted to the on-board recording system.

These hydrophones are unable to distinguish between the signal emitted by the acoustic source and underwater background noise which is particularly marked at the sea surface. In order to minimise interference of the sea surface noise with the hydrophone recording, the streamers are towed underwater. The deeper the tow depth, the quieter the streamer; however this also results in a narrower bandwidth of received data. Typical streamer operating depth ranges from 4 – 5 m for shallow high resolution surveys in relatively good weather, to 8 – 12 m for deeper penetration and lower frequency targets in more open waters. The streamers for the Nikau 3D Seismic Survey will extend approximately 8 km behind the seismic vessel and separated by 150 m.

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

## 2.2 Nikau 3D Seismic Survey

The Nikau 3D Seismic Survey is proposed to take place in the North Taranaki Bight (**Figure 1**). Water depths within the Operational Area range from 114 to 150 m.

The seismic vessel *PGS Apollo* (**Figure 4**) will be used to undertake the survey. Seismic survey parameters are summarised in **Table 3** and discussed below.

During the Nikau 3D Seismic Survey, up to 10 solid streamers of approximately 8 km in length will be towed from the seismic vessel. Each streamer will be separated by 150 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 which results in less infill lines and a reduction in the cumulative sound energy introduced into the marine environment. During the survey, the *PGS Apollo* will be travelling at approximately 4.5 knots.

The acoustic source will be comprised of two sub-arrays, with a total effective volume of 3,260 in$^3$. The sub-arrays will be towed at a depth of 7 m below the sea surface. Sound Transmission Loss Modelling (STLM) was conducted based on the specific acoustic source volume and array configuration described here. The STLM is further discussed in **Section 5.1.2.1** and the full STLM results are attached as **Appendix C**.

The acoustic source will have an operating pressure of 2,000 psi and will be activated at a source-point interval of 16.67 m. For a vessel speed of 4.5 knots, this equates to source activation every 8 seconds.

During the Nikau 3D Seismic Survey, the seismic source will remain off during line turns and will only be activated for the purpose of source testing during standard maintenance routines, and soft starts on approaching the start of a new line.

OMV are planning to commence the proposed Nikau 3D Seismic Survey in November 2016. Subject to weather conditions and marine mammal encounters within mitigation zones, the seismic operations will be conducted 24 hours per day, seven days per week. This survey is expected to take approximately 30 days to complete.

The technical specifications of the *PGS Apollo* are provided in **Table 3**. Two smaller support/chase vessels will also be contracted for the duration of the survey and will be in close proximity to the seismic vessel at all times with the exception of those periods when either support vessel is needed for a port call.

Survey operations can be divided into four main components:

- Mobilisation of seismic vessel to Operational Area;

- Deployment of acoustic equipment: Streamer and source array deployment is expected to take approximately four days. Once deployed the MMOs will begin the requisite pre-start observations as required under the Code of Conduct when arriving at a new location (**Section 3.4**), followed by a soft start;
- Data Acquisition: Once full acquisition is underway, two MMOs and two PAM operators will maintain watch for marine mammals; and
- Demobilisation: Once acquisition is complete, the seismic array and streamers will be retrieved and the vessel will head to its next destination or return to port.

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

**Table 3: Nikau 3D Seismic Survey Specifications**

| Parameter | Specifications |
|---|---|
| Total array volume | 3,260 in$^3$ |
| Maximum predicted output | 211 dB re 1μPa/Hz @ 1m |
| Number of sub-arrays | 2 |
| Number of acoustic sources per sub-array | 11 - 11 |
| Array length | 14 m |
| Array width | 12 m |
| Nominal operating pressure | 2,000 psi |
| Source Frequency | 16.67 m |
| Tow Depth | 7 m |
| Number of streamers | 10 |
| Streamer length | 8.1 km |
| Streamer manufacturer/model | Solid |
| Streamer towing depth | 20 m |

**Table 4: *PGS Apollo* Technical Specifications**

| General Specifications | |
|---|---|
| Vessel Name | *PGS Apollo* |
| Vessel Owner | OMP Apollo AS |
| Maritime Operator | PGS |
| Engine Details | Twin CP propeller plant with nozzle and propeller shaft (Rolls Royce) |
| Fuel Capacity | 1,452 m3 HFO + 640 m3 MGO |
| **Dimensions and capacities** | |
| Vessel Length | 106.8 m |
| Vessel Beam | 19.2 m |
| Max Draft | 6.5 m |
| Gross Tonnage | 7.131 tonnes |
| Cruising Speed | 17 knots |

**Figure 4: Seismic Vessel – *PGS Apollo***

## 2.3 Navigational Safety

During the Nikau 3D Seismic Survey, the seismic vessel will be towing up to 10 streamers of approximately 8 km in length, severely restricting its manoeuvrability. Avoidance of collision will rely on all vessels obeying the International Regulations for the Prevention of Collisions at Sea (COLREGS) 1972. COLREGS is implemented in New Zealand waters under the Maritime Transport Act 1994. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the presence of the seismic vessel in the Operational Area and the vessel's restriction in ability to manoeuvre while the streamers are deployed. The *PGS Apollo* has Automatic Identification System (AIS) technology on-board, allowing the vessel to receive information about the positions of other vessels and to transmit information about its position to others.

During the consultation process (see **Section 1.3**), known users of the Operational Area were provided with information about the survey. Additionally, OMV will update fishing fleets on their intended schedule closer to survey commencement. Furthermore, support vessels will be utilised to notify boats that are unaware of the seismic operations as necessary. In accordance with International Maritime Law, the survey vessels will display the appropriate lights and day shapes while undertaking the survey. Tail buoys equipped with a light and radar reflector will mark the end of the streamers, allowing for detection during day and night.

## 2.4 Survey design – Alternatives and Mitigations

The majority of seismic surveys conducted worldwide use acoustic sources as they generate low frequency signals allowing the formation of images of the underlying geology below the seafloor. OMV will use a 'bolt acoustic source' for the Nikau 3D Seismic Survey, with the acoustic source consisting of two 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. OMV has the option to utilise a 4130, 3260 or 2820 in$^3$ acoustic source and were aware of ensuring that their survey is using the lowest possible acoustic source volume to minimise the effects on marine mammals whilst still achieving the data acquisition objectives of the Nikau 3D Seismic Survey.

A source level of 3,260 in$^3$ was identified as an optimum power level given the survey objectives.

OMV made the decision to truncate the Operational Area to keep all seismic survey acquisition outside of the marine mammal sanctuary.

Seismic operations will be undertaken in late spring/summer months to try and take advantage of settled weather. This timing not only makes for more amenable working conditions for crew, but also serves to reduce environmental effects in the following ways:

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

# 3 LEGISLATIVE FRAMEWORK

The New Zealand Government's oil, gas, mineral and coal resources are administered by New Zealand Petroleum & Minerals whose role it 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 Nikau 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, 2016).

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

## 3.2 Marine Mammals Protection Act 1978

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

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

The closest marine mammal sanctuary to the proposed Operational Area is the West Coast North Island Marine Mammal Sanctuary which is located approximately 5.5 km to the southeast. A full description of the sanctuary can be found in **Section 4.3.3**.

In the Territorial Sea and in waters outside the EEZ, but over the Continental Shelf, compliance with the Code is voluntary and is neither legally binding nor enforceable. The Nikau 3D Seismic Survey will occur solely within the EEZ and OMV will comply with the Code of Conduct through the entire Operational Area.

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

The EEZ Act came into force in June 2013, and established the first comprehensive environmental consenting regime for activities in 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* (the Code of Conduct);
- **Non-notified discretionary** – the activity can be undertaken if the applicant obtains a marine consent from the Environmental Protection Authority (EPA), who may grant or decline the consent and place conditions on the consent. The consent application is not publically notified and the EPA has a statutory timeframe of 60 working days in which to process the application;
- **Discretionary** – the activity may be undertaken if the applicant obtains a marine consent from the EPA. The consent application will be notified, submissions will be invited and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 140 working days in which the EPA must assess the consent application; and
- **Prohibited** – the activity may not be undertaken.

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

## 3.4 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations

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

The Code of Conduct aims to:

- Minimise disturbance to marine mammals from seismic survey activities;

- Minimise noise in the marine environment arising from seismic survey activities;
- Contribute to the body of scientific knowledge on the physical and behavioural impacts of seismic surveys on marine mammals through improved, standardised observations and reporting;
- Provide for the conduct of seismic surveys in 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 Nikau 3D Seismic Survey is classified as a Level 1 survey. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

### 3.4.1 Notification

The notification requirements of the Code of Conduct have been met by OMV. A letter was received by the Director-General of Conservation on 5 September 2016 notifying DOC of OMVs intentions to carry out the Nikau 3D Seismic Survey.

### 3.4.2 Marine Mammal Impact Assessment

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

- Describe the activities related to the survey;
- Describe the state of the local environment in relation to marine species and habitats, with a particular focus on marine mammals;
- Identify the actual and potential effects of the activities on the environment and existing interests, including any conflicts with existing interests;
- Identify the significance (in terms of risk and consequence) of any potential negative impacts and define the criteria used in making each determination;
- Identify persons, organisations or Tangata Whenua with specific interests or expertise relevant to the potential impacts on the environment;
- Describe any consultation undertaken with persons described above, and specify those who have provided written submissions on the proposed activities;
- Include copies of any written submissions from the consultation process;
- Specify any possible alternative methods for undertaking the activities to avoid, remedy or mitigate any adverse effects;
- Specify the measures that the operator intends to take to avoid, remedy or mitigate the adverse effects identified;
- Specify a monitoring and reporting plan; and
- Specify means of coordinating research opportunities, plans and activities relating to reducing and evaluating environment effects.

### 3.4.3 Areas of Ecological Importance

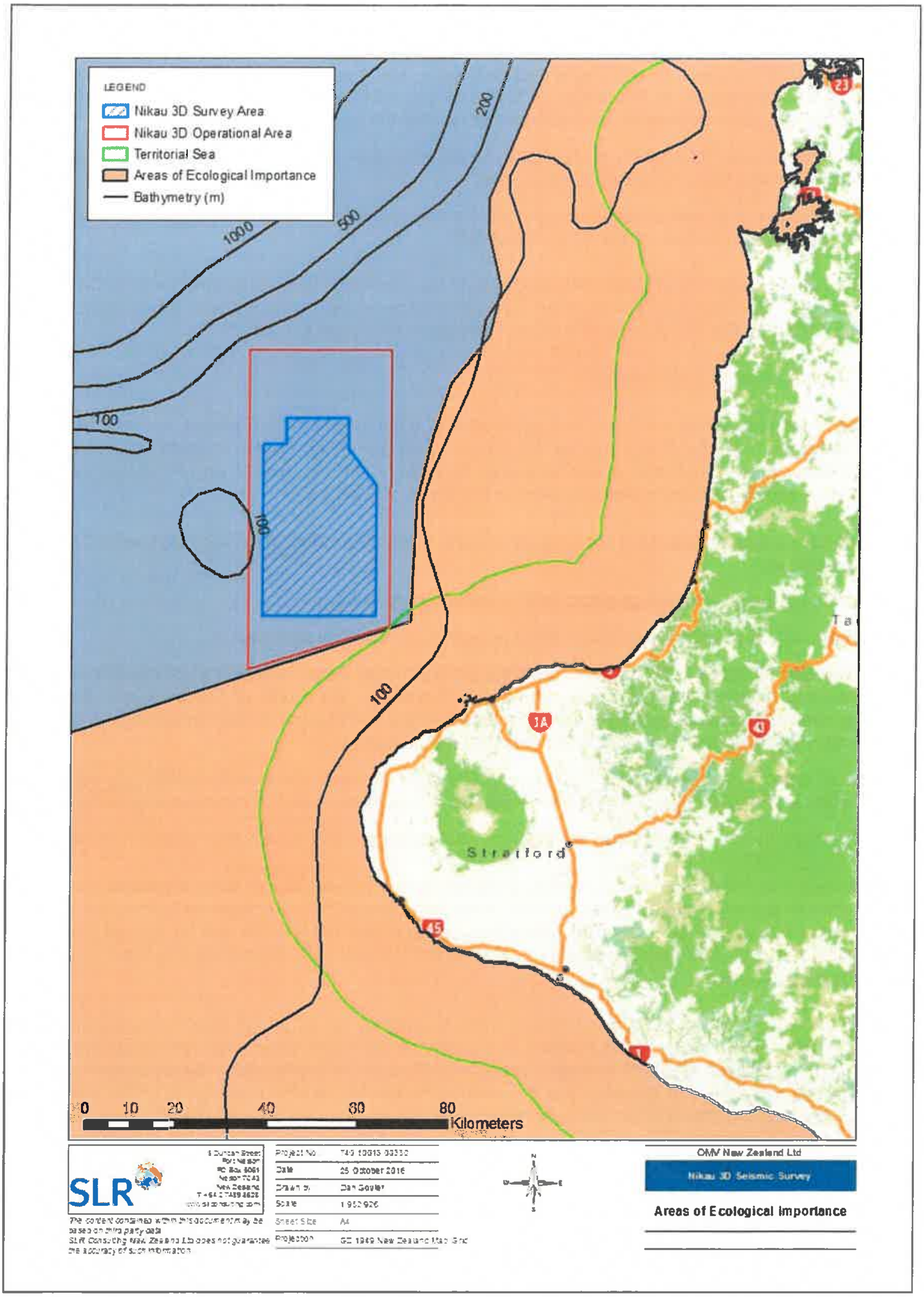
Any seismic survey operations within an Area of Ecological Importance require more comprehensive planning and consideration, including the development of additional mitigation measures.

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

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

The Nikau 3D Seismic Survey will occur beyond the Areas of Ecological Importance (**Figure 5**); however, as best practice OMV will operate the survey taking into account the sensitive area inshore of the Operational Area. A summary of measures that OMV will implement to offset their potential effects in this area is provided in **Section 6**.

**Figure 5: Relationship between the Operational Area and Area of Ecological Importance**



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

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

If the modelling predicts that these thresholds could be exceeded, then consideration must be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. Results from the Nikau 3D Seismic Survey STLM are discussed in **Section 5.1.2.1**.

### 3.4.4 Observer Requirements

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

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

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

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

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

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

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

### 3.4.5 Operational and Reporting Requirements

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

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

### 3.4.6 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.

**Table 5: Operational Duties of MMOs and PAM Operators**

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

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

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

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

### 3.4.7 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.

### 3.4.8 Delayed Starts and Shutdowns

The results of the STLM indicated that the standard 1.0 km mitigation zone for delayed starts and shutdowns (as outlined in the Code of Conduct) is not sufficient to protect marine mammals from all potential effects during the Nikau 3D Seismic Survey. For this reason, OMV has adopted a larger mitigation zone during the Nikau 3D Seismic Survey to protect marine mammals against behavioural effects. The mitigation zones that will be used are outlined below.

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

If, during pre-start observations or while the acoustic source is activated (including during soft starts), a qualified observer detects at least one Species of Concern with 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**

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.

# 4 ENVIRONMENTAL DESCRIPTION

## 4.1 Physical Environment

### 4.1.1 Meteorology

New Zealand climate is highly variable and ranges from a warm subtropical climate in the north to cool temperate in the far south. Anticyclones systems travel from west to east and cross the north Island of New Zealand at regular intervals (approximatively 1 week). There is a slight seasonal variation in their trajectories which tend to be more northerly in the spring and southerly in the autumn and winter.

Between the anticyclones are troughs of low pressure orientated northwest to southeast. Associated cold fronts are accompanied by increased cloud cover, intensifying north-westerly winds, and precipitation which persists until the front passes eastward. Yet another weather pattern occurs after the passage of the front this time with the appearance of cold rain and south-westerly winds.

The location of the Operational Area in the North Taranaki Bight will expose it to intense weather systems from the Tasman Sea. It will therefore be subject to high winds and seas. The strongest and most frequent winds and swells are generally oriented from the west to southwest. Although weather in the Operational Area has few climatic extremes it can be extremely changeable: winters are generally more unsettled.

New Plymouth weather conditions have been used as indicative for the Operational Area as this is the closest city on the exposed west coast of central New Zealand. 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, 2016

### 4.1.2 Currents and Waves

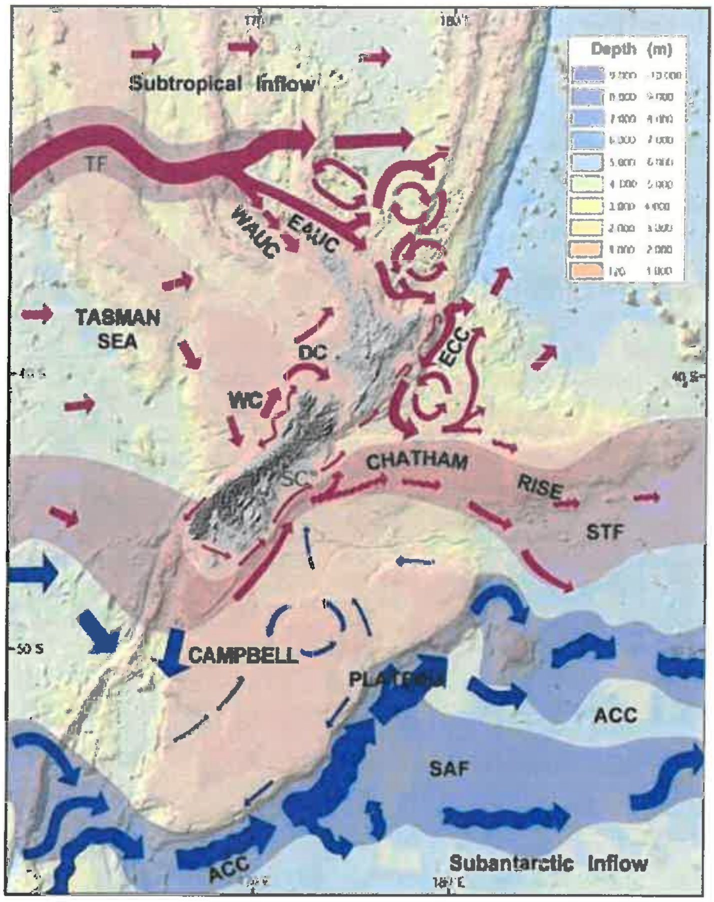
The coastal current regime in New Zealand has three main types of current. These are wind-driven currents, low-frequency currents and tidal currents. Along with local bathymetry, the strength and direction of these three currents define the net current flow.

Westerly winds blow across the South Pacific Ocean, generating eastward flowing currents which dominate the New Zealand current regime. Specifically, New Zealand is exposed to the southern branch of the South Pacific subtropical gyre. The gyre has an anti-clockwise circulation driven by the southeast trade winds to the north and the Roaring Forties to the south and modified by the spin of the earth (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 flows from the west coast of the South Island up to the west coast of the North Island where it weakens and becomes subject to seasonal variability. The convergence zone of the two currents is highly variable (Brodie, 1960; Ridgway, 1980; Stanton, 1973).

Seasonal variation in the West Auckland Current and Westland Current results in varying temperatures and salinity off the west coast of central New Zealand. 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).

**Figure 6 Ocean Circulation around the New Zealand Coastline**



Source: Te Ara, 2016

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 varying in size and direction with season. Large waves from Tasman Sea storms also contribute to the wave energy (MacDiarmid *et al.*, 2011).

Wave heights in the North Taranaki Bight show a seasonal cycle, with mean significant wave heights peaking in late winter (August and September) and are lowest in late summer (MacDiarmid *et al.*, 2011). Wave heights in excess of 8 m can occur during stormy conditions, particularly in the winter and early spring (MacDiarmid *et al.*, 2011).

### 4.1.3 Thermoclines and Sea Surface Temperature

In the warm months of spring and summer, radiation from the sun heats the top layers of the water column (up to 40-50 m depth). This can result in the appearance of thermal stratification known as the thermocline. The presence of a thermocline and the nature of the stratification in the water column results from local conditions such as which will either enhance the structure (tides, currents) or create mixing and breakdown the thermocline (tide, currents, storm events).

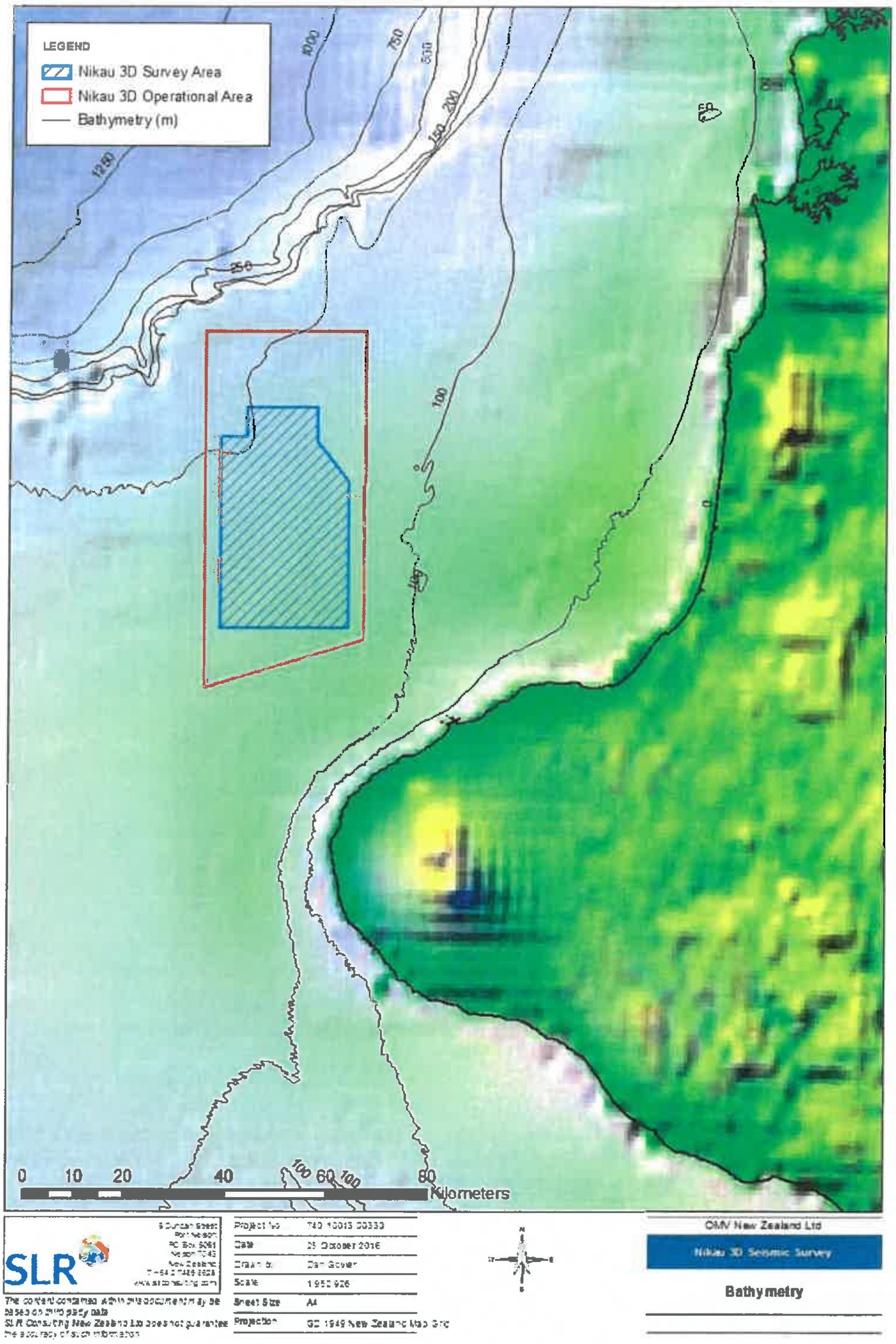
Thermoclines can be acoustically reflective and as a result are visible in processed seismic data. A sudden change in water temperature (as is the case when a thermocline is present in the water column) creates a discontinuity in the acoustic impedance of the water. A 1°C change in water temperature can alter the speed of sound by as much as 3 m per second (Simmonds *et al.*, 2004).

### 4.1.4 Bathymetry and Geology

New Zealand's coastline gives way to a shelf which gently slopes into the ocean. This is known as the continental shelf and it extends out to a water depth of 100–200 m. Past the shelf, lies the continental slope which descends more or less rapidly from the edge of the shelf to abyssal depths (4,000 m and beyond). Submarine canyons punctuate the surface of the continental slope especially in areas of steep gradient (e.g. Kaikoura). 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.*, 2011). The Taranaki continental shelf has a 150 km wide opening to the Tasman Sea, occupies 30,000 km$^2$, and slopes gently towards the west with an overall gradient of <0.1° (Nodder, 1995). Through the Operational Area the seabed slopes towards the west. The shallowest water (114 m) occurs on the southeast section of the Operational Area, but reaches depths of up to 150 m in the northwest (**Figure 7**).

**Figure 7** **Bathymetry of the Operational Area**



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

Of the eight sedimentary basins underlying New Zealand's continental shelf with known or potential hydrocarbons present (**Figure 8**), only the Taranaki Basin has produced commercial quantities of oil and gas to date.

**Figure 8 New Zealand's Sedimentary Basins**

Source: GNS, 2016.

The Operational Area traverses the Taranaki Basin. This basin 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 (NZP&M, 2013).

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.

Surficial marine sediments across the Taranaki shelf follow 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 in the South Taranaki Bight (MacDiarmid *et al.*, 2011).

## 4.2 Biological Environment

### 4.2.1 Plankton

The term 'plankton' designates drifting organisms that inhabit the pelagic zone (water column) of the world's oceans. Plankton are the primary producers in the ocean and as such form the foundation of the marine food web. Although some plankton are known to have limited movement within the water column, most drift passively with ocean currents which define their horizontal and vertical distribution.

'Plankton' is a broad group which encompasses animals, algae, protists, archaea and bacteria. These are split into three main functional groups: bacterioplankton – free-floating bacteria (important in nutrient cycling); phytoplankton – free-floating plants (capable of photosynthesis); and zooplankton – free-floating animals (includes larval stages of larger animals).

Levels of primary productivity (i.e. phytoplankton production) have a knock-on effect up the food chain by attracting grazers then predators to the area. Areas of high primary productivity can be detected using satellite imagery (using Chlorophyll α as a proxy for primary productivity). This type of imagery around New Zealand has highlighted the existence of great seasonal and regional variation throughout the Taranaki Basin. A consistent annual phytoplankton bloom takes place in the spring months off the west coast of New Zealand. Chlorophyll α levels then proceed to drop to their lowest annual level at the end of the summer and build up again throughout the winter in order to peak once again with the onset of spring (Murphy *et al.*, 2001).

Large scale physical phenomena such as tidal mixing, river plumes and surf beach processes are all likely to impact the distribution and biomass of zooplankton in and around the Operational Area. Dominant species found in the vicinity of the Operational Area include *Oithnoa similis* and *Paracalanus c.f. indicus*. Blooms in species such as salps and appendicularians can periodically lead to these species also becoming dominant in the area (Bradford-Grieve & Stephens, 2013).

### 4.2.2 Invertebrates

Over 400 species of invertebrate are known to inhabit the shores adjacent to the Operational Area (Hayward *et al.*, 1999). Species number and diversity tends to increase towards the shore, with highest numbers in the near-shore area (MacDiarmid *et al.*, 2011). Overall, the sandy exposed shores present to the north of the region (around Mokau) present lower species diversity and are dominated by species of mobile invertebrates (Hayward *et al.*, 1999). Southwards, shores become less exposed and harder which results in an increase the development of sessile invertebrate communities and an increase in species diversity (Hayward *et al*, 1999). The Parininihi Marine Reserve (directly inshore of the Operational Area) is particularly important for invertebrates such as sponges and rock lobsters. The submerged caves, over-hangs and canyons within the reserve also support diverse communities of bryozoans, hydroids, anemones, and soft corals (DOC, 2016). Offshore in North Taranaki, up to depths of 20 m, dominant invertebrate species are isopods and amphipods (Hayward et al., 1999).

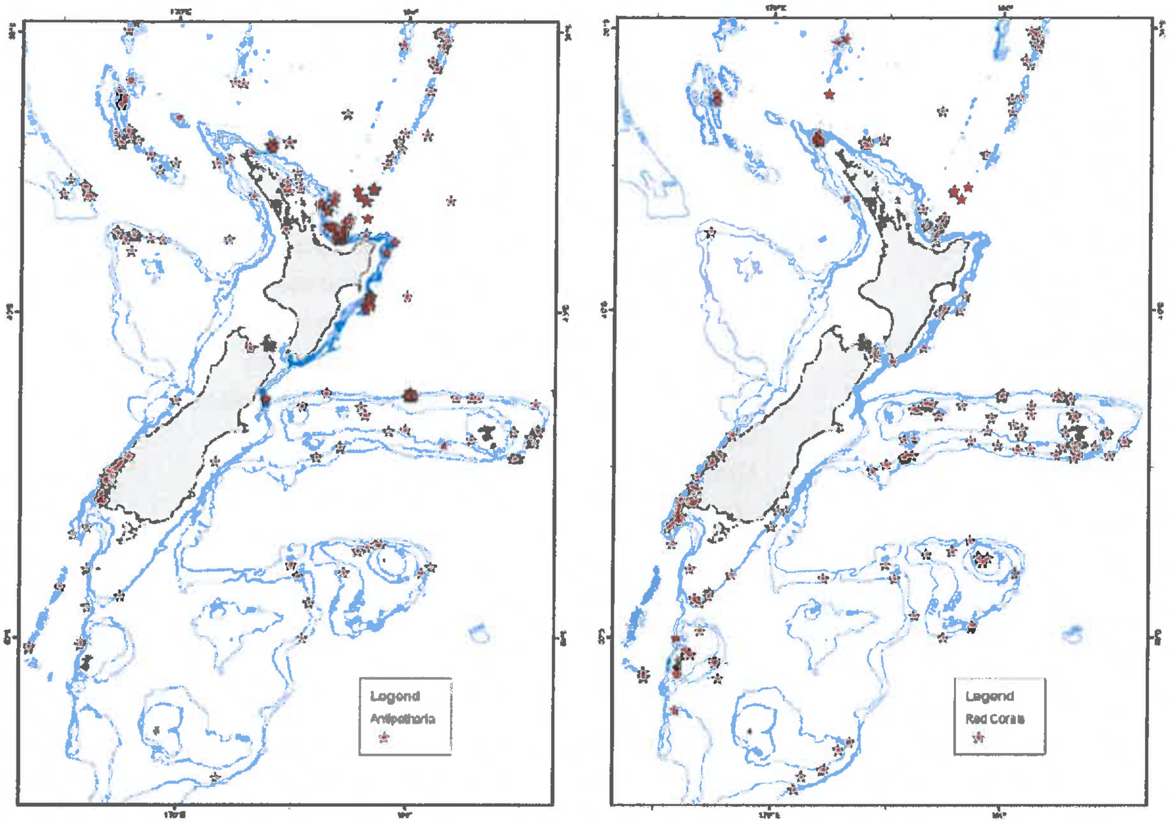
Beyond the 20 m isobath (approximatively 4 km offshore), the offshore benthic ecosystems in the North Taranaki Bight are generally characterised by soft sand/mud substrates supporting limited diversity and abundance of species dominated by polychaete worms, heart urchins and hermit crabs (TRC, 2009; Shell Todd, 2002). Although there is limited literature on the offshore invertebrate fauna of the North Taranaki Bight, it is presumed that these will be similar to those present in the South Taranaki Bight: mainly polychaete worms, cumaceans, amphipods (small crustaceans), and bivalves. The habitat is considered to be relatively homogenous with low levels of diversity (Asher, 2014; Skilton, 2014). Notably, spiny rock lobster (*Jasus verreauxi, Jasus edwardsii*) are known to occur in the North Taranaki Bight. As is the case throughout New Zealand, these species undergo periodic southward migrations (Booth, 1980).

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 occur either as individuals or as compact colonies of individual polyps and can live for hundreds of years. 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 are the most relevant to this MMIA.

Within New Zealand's EEZ, black coral and stylasterid hydrocoral (formerly known as red coral) are protected under the Wildlife Act 1953. Within New Zealand waters, 58 species of black coral have been identified, and although their depth and geographical distributions have not been systematically analysed, it appears that most live on seamounts or other hard substrate in depths ranging from 200 to 1,000 m.

NIWA have developed a database of black coral distribution around New Zealand based on records from commercial fishing by-catch. From this data the presence of black and stylasterid coral appears to be greatest in the north and east of New Zealand. There are no significant densities of black coral or stylasterid coral in the Operational Area (**Figure 9**).

**Figure 9** **Records of Black Corals (left) and Stylasterid Corals (right) in New Zealand**



**Source:** Consalvey *et al.* (2006)

### 4.2.3 Fish Species

Fish populations from the Operational Area are represented by various demersal and pelagic species, most of which are widely distributed from north to south and from shallow coastal water to beyond the shelf edge. The fish species richness in Taranaki waters has been reported to be moderate on a national scale, with no nationally rare or threatened species present (MacDiarmid *et al.*, 2011).

Over the summer months, a number of larger pelagic species visit the Operational Area waters. Examples can include 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 7**. The information for this summary table was collated from the NABIS database, O'Driscoll *et al.*, (2003); and Hurst *et al.*, (2000). Over 1,000 species of fish occur in New Zealand waters (Te Ara, 2016a), therefore it is worth noting that **Table 7** does not provide an exhaustive list of all species present within the Operational Area.

**Table 7 Fish Species Potentially Present in the Operational Area**

| Common Name |
|---|
| Ahuru |
| Albacore tuna |
| Anchovy |
| Barracouta |
| Basking shark |
| Bass |
| Bigeye tuna |
| Black cardinalfish |
| Black marlin |
| Blue cod |
| Blue mackerel |
| Blue marlin |
| Blue moki |
| Blue shark |
| Blue warehou |
| Bluenose |
| Brill |
| Broadbill swordfish |
| Bronze whaler shark |
| Brown stargazer |
| Carpet shark |
| Common warehou |
| Crested bellowsfish |
| Cucumber fish |
| Dark ghost shark |
| Giant stargazer |
| Eagle ray |
| Elephant fish |
| Escolar |
| Frostfish |
| Gemfish |
| Grey mullet |
| Golden mackerel |
| Hake |
| Hammerhead shark |
| Hapuku |
| Hoki |
| Horse mackerel |
| Jack mackerel |
| John dory |
| Kahawai |
| Kingfish |
| Leatherjacket |
| Lemon sole |
| Ling |
| Long-finned beryx |
| Lookdown dory |
| Mako shark |
| Moonfish |
| Murphy's mackerel |
| NZ sole |
| Northern spiny dogfish |
| Pacific Bluefin tuna |
| Pale ghost shark |
| Pilchard |
| Porae |
| Porcupine fish |
| Porbeagle shark |
| Ray's bream |
| Red cod |
| Red gurnard |
| Red snapper |
| Redbait |
| Red mullet |
| Rig |
| Rough skate |
| Rubyfish |
| Sand flounder |
| Scaly gurnard |
| School shark |
| Short-tailed black ray |
| Silver dory |
| Silverside |
| Silver warehou |
| Sea perch |
| Skipjack tuna |
| Smooth skate |
| Snapper |
| Spiny dogfish |
| Sprat |
| Spotted stargazer |
| Squid |
| Striped marlin |
| Tarakihi |
| Thresher shark |
| Trevally |
| Turbot |
| Two saddle rattail |
| White shark/great white shark |
| Witch |
| Yellow-eyed mullet |

Areas where fish spawn or pup (species such as sharks give birth to live offspring, also known as pupping) may be disproportionately important to fish populations. Any disruptions to spawning activity may result in reduced recruitment (Morrison *et al.*, 2014). Information on the spawning and pupping of New Zealand's fish is very limited. While the spawning/pupping activities of some species (such as hoki and orange roughy) are well known, insufficient data exists for the majority of species. Spawning/pupping locations are often based on catch of spent or ripe running females in research trawl tows. Species potentially spawning/pupping within the Operational Area include; barracouta, blue mackerel, blue warehou, giant stargazer, grey mullet, jack mackerel (*Trachurus declivis,* and *T. novaezeandiae*), Murphy's mackerel, John dory, red gurnard, rig, school shark, snapper, tarakihi, lookdown dory, black cardinalfish, and sprat (Hurst *et al.*, 2000; O'Driscoll *et al.*, 2003; Morrison *et al.*, 2014).

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

Long-finned and short-finned eels can be found in the freshwaters of the North Island's west coast. These eels live the majority of their lives in freshwater systems until they have matured to breeding size. Once mature, adult eels undergo physical changes and migrate to spawning areas in the Pacific. Although the exact location of spawning sites is unknown, Tonga is thought to be important for eel spawning (Te Ara, 2016b). Scientific information on the migration routes of long-finned and short-finned eels is limited; however, they are believed to migrate from New Zealand to spawning grounds by various routes, with larvae returning via ocean currents past New Zealand's east and west coasts (PCE, 2013). Long-finned and short-finned eels are semelparous; characterised by a single reproductive episode before death, therefore adults do not return to New Zealand after spawning.

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

### 4.2.4 Cetaceans

Forty eight cetacean taxa (whales and dolphins) can be encountered in New Zealand waters (Baker *et al.*, 2016). These include specimen of both suborders: toothed whales (odontocetes) and baleen whales (mysticetes)

Baleen whales tend to be larger animals and employ a characteristic feeding technique (after which they are named) which involves using the plates of baleen in their upper jaw as a sieve to filter plankton from the water column. In contrast, odontocetes have teeth and are known to hunt and navigate in large groups. In order to locate prey (and navigate their environment) odontocetes use echolocation. They direct sounds ("clicks") into their environment and interpret the reflected sound waves. Although mysticetes don't echolocate, they do rely heavily on sound for communication, sometimes across great distances. This dependence on sound for feeding and navigation makes cetaceans vulnerable to the effects of anthropogenic noise: therefore precautions must be taken during seismic surveys in order to minimise potential effects. Mitigation measures for the Nikau 3D Seismic Survey are summarised in **Section 6**.

#### 4.2.4.1 Cetacean Distribution in the North Taranaki Bight

Cetaceans are difficult to study. Their habitat is often inaccessible and they engage in behaviours such as large scale migration and deep-diving which present serious logistical challenges to any study attempts. As a result of these difficulties, it is crucial that multiple sources of information should be considered when assessing cetacean occurrence. The different available types of data include detection data (acoustic detections or sightings from dedicated and opportunistic surveys), stranding information, and knowledge of migration paths and habitat preferences of each species.

Cetacean distribution data requires a certain level of interpretation and particular caution should be exercised when considering regions exhibiting low levels of sighting data. Low levels of data do not necessarily indicate an absence of cetaceans; rather it could simply reflect a lack of observer effort. Typically, these 'data gaps' occur in areas that are either inaccessible or have relatively low levels of boat traffic. The DOC sightings database (which is cited throughout this section) is the most comprehensive source of cetacean sightings data in New Zealand but still does not include all distribution data.

Similar caution should be exercised when interpreting strandings data. Although this type of data gives an excellent (albeit broad) indication of species occurrence, it cannot be relied upon for full detailed species distribution. Stranding data should therefore be interpreted as indicative only, with greater emphasis placed on live sighting data.

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

The data sources utilised to identify cetaceans potentially present within the Operational Area were: the DOC sighting database, the DOC stranding database, and readily available distribution accounts from the literature.

The DOC sighting database includes over 8,000 sightings of marine mammals, of which numerous records were contributed by previous seismic surveys. **Figure 10** provides a summary of all sightings from the database in the vicinity of the Operational Area.

**Figure 11** gives a summary of the DOC stranding database and clearly illustrates the fact that strandings occur in all regions of New Zealand. The data presented is comprised of 40 cetacean species and four pinniped (seal) species. An assessment of the DOC stranding database in the early 1990s concluded that three species, pilot whales, false killer whales and sperm whales, accounted for 88% of all whale strandings (Brabyn, 1991); hence many species are only represented in the stranding database in very small numbers.

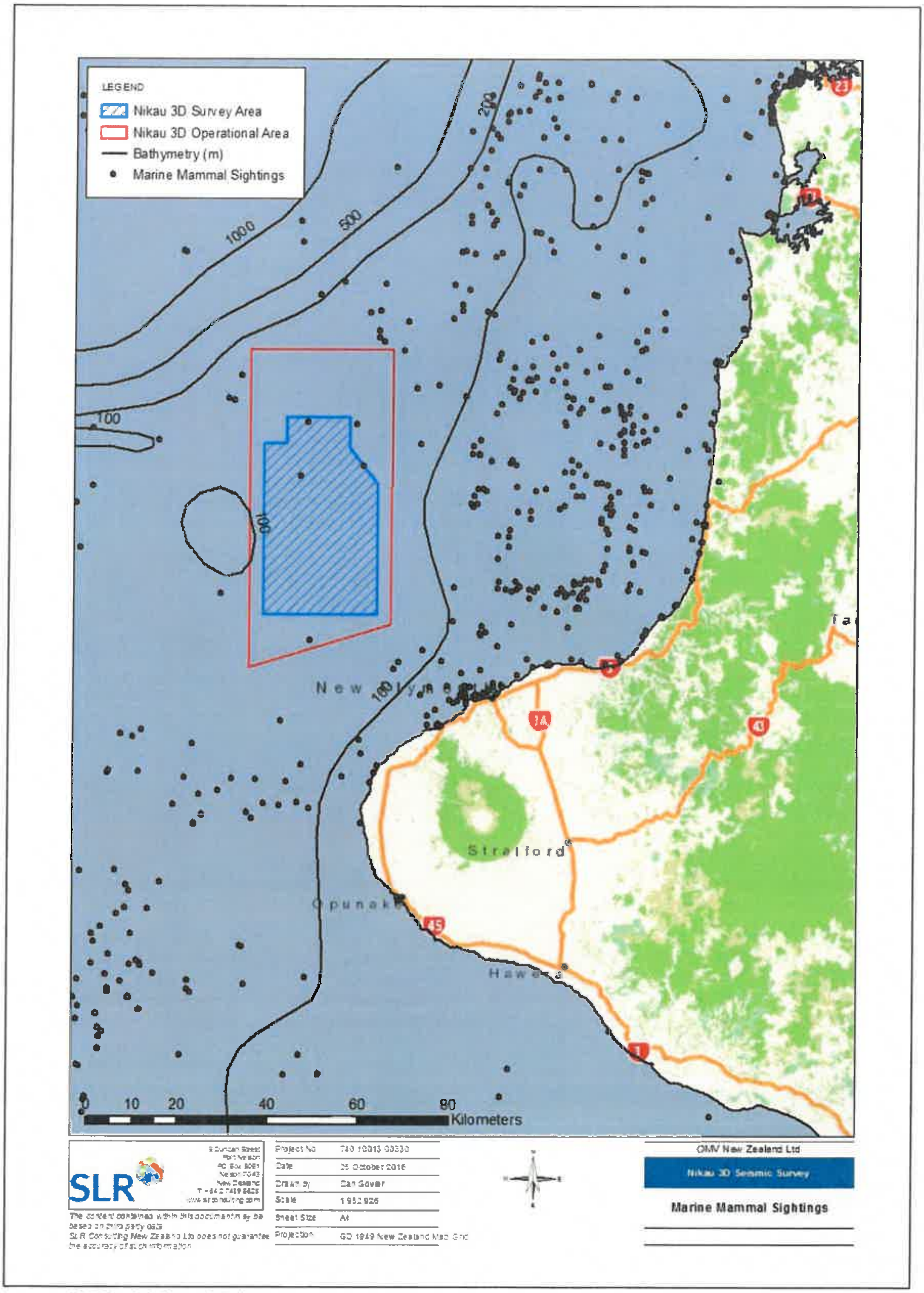
Based on the available information, **Table 8** provides summarises the likelihood of cetacean species presence in the Operational Area, and a basic ecological summary for those more commonly occurring species is provided in **Section 4.2.4.3**.

The criteria used to assess the likelihood of a species being present in the Operational Area are as follows:

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

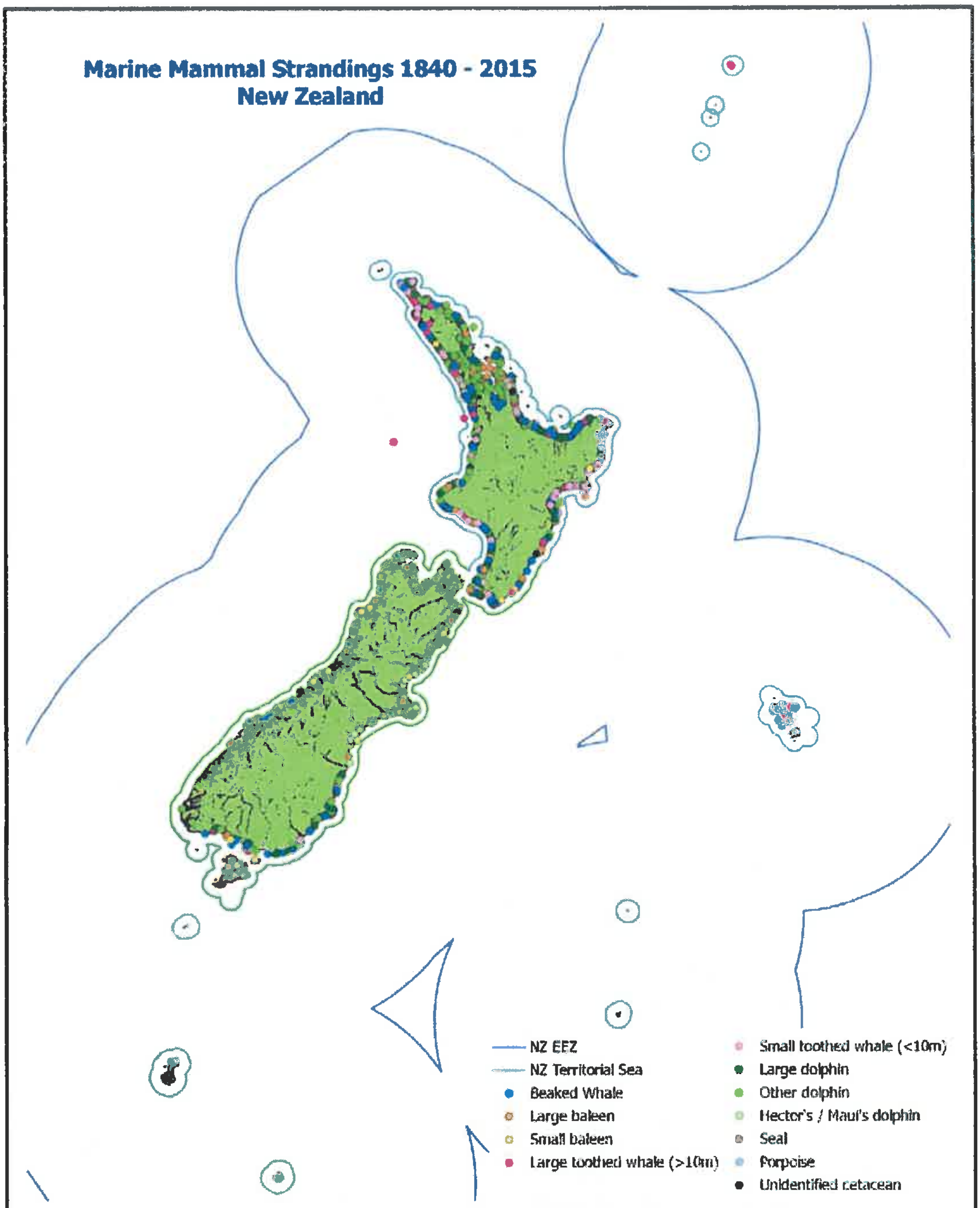
  Species that are represented in the DOC sightings and/or stranding record from the Operational Area and which are classified as 'data deficient' in the New Zealand Threat Classification System.
- **Occasional Visitor**
  Species that are represented in the DOC sightings and/or stranding record from the Operational Area, but are listed as 'migrants' in the New Zealand Threat Classification System.
- **Rare Visitor**
  Species that are present in 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 'vagrants' in the New Zealand Threat Classification System
- **Unlikely**
  Species that are not present in the DOC sightings and/or stranding record from the Operational Area.

Figure 10 Cetacean sightings in the vicinity of the Operational Area



Source: DOC sighting database

**Figure 11 Summary of Marine Mammal Strandings around New Zealand.**



Beaked whales include 12 species: Andrew's beaked whale, Arnoux's beaked whale, Blainville's beaked whale, Cuvier's beaked whale, Ginkgo-toothed beaked whale, Gray's beaked whale, Hector's beaked whale, Shepherd's beaked whale, Southern bottlenose whale, Spade-toothed whale, Strap-toothed whale, True's beaked whale
Large baleen include seven species: Blue whale, Bryde's whale, Fin whale, Humpback whale, Pygmy blue whale, Sei whale, Southern right whale
Small baleen include three species: Antarctic minke whale, Common minke whale, Pygmy right whale
Large toothed whales include one species: Sperm whale
Small toothed whales include two species: Dwarf sperm whale, Pygmy sperm whale
Large dolphins include six species: False killerwhale, Killer whale, long-finned pilot whale, Melon-headed whale, Pilot whale, Risso's dolphin, short-finned pilot whale
Other dolphins include eight species: Common bottlenose dolphin, Dusky dolphin, Hourglass dolphin, Pantropical spotted dolphin, Rough-toothed dolphin, Short-beaked common dolphin, Southern right whale dolphin, Striped dolphin
Porpoise includes one species: Spectacled porpoise
Seals include four species: Crabeater seal, Hooker's sea lion, Leopard seal, New Zealand fur seal

**Source:** Department of Conservation, 2015

**Table 8 Likelihood of occurrence of cetaceans in the Operational Area**

| Common Name | Scientific Name | National status (Baker *et al.* 2016) | Qualifier | IUCN Status www.redlist.org | Species of Concern (DOC, 2013) | DOC stranding database | DOC sightings database | Presence in the Study Area |
|---|---|---|---|---|---|---|---|---|
| Andrew's beaked whale | *Mesoplodon bowdoini* | Data deficient | SO | Data deficient | Yes | ✓ | ✗ | Possible |
| Antarctic fur seal | *Arctocephalus gazella* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Antarctic minke whale | *Balaenoptera bonaerensis* | Not threatened | DP, SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Arnoux's beaked whale | *Berardius arnouxi* | Migrant | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Blainville's beaked whale | *Mesoplodon densirostris* | Data deficient | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Blue whale | *Balaenoptera musculus* | Migrant | TO | Endangered | Yes | ✗ | ✓ | Occasional visitor |
| Bottlenose dolphin | *Tursiops truncatus* | Nationally endangered | DE,Sp, SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Bottlenose dolphin (Kermadec Islands) | *Tursiops sp. (Kermadecs)* | Data deficient | SO | N/A | No | ✗ | ✗ | Unlikely |
| Bryde's Whale | *Balaenoptera edeni* | Nationally critical | SO | Data deficient | Yes | ✓ | ✗ | Likely |
| Common dolphin | *Dolphinus dolphis* | Not threatened | DP,SO | Data deficient | No | ✓ | ✓ | Likely |
| Crab eater seal | *Lobodon carcinophaga* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Cuvier's beaked whale | *Ziphius cavirostris* | Data deficient | SO | Least concern | Yes | ✓ | ✗ | Possible |
| Dusky dolphin | *Lagenorynchus obscurus* | Not threatened | SO | Data deficient | No | ✗ | ✓ | Likely |
| Dwarf minke whale | *Balaenoptera acutorastrata* | Not threatened | Inc, SO | Least concern | Yes | ✗ | ✗ | Unlikely |
| Dwarf sperm whale | *Kogia sim* | Vagrant | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| False killer whale | *Pseudorca crassidens* | Not threatened | DP, SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Fin Whale | *Balanoptera physalus* | Migrant | TO | Endangered | Yes | ✗ | ✓ | Occasional visitor |
| Fraser's dolphin | *Lagenodelphis hosei* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Gingko-toothed whale | *Mesoplodon ginkgodens* | Vagrant | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Gray's beaked whale | *Mesoplodon grayi* | Not threatened | DP, SO | Data deficient | Yes | ✓ | ✗ | Likely |
| Hector's beaked whale | *Mesoplodon hectori* | Data deficient | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Hector's Dolphin | *Cephalorynchus hectori* | Nationally endangered | CD | Endangered | Yes | ✗ | ✓ | Likely |
| Hourglass dolphin | *Lagenorynchus cruciger* | Data deficient | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Humpback whale | *Megatpera novaeangliae* | Migrant | SO | Least concern | Yes | ✗ | ✓ | Occasional visitor |
| Killer whale | *Orcinus orca* | Nationally critical | DP, SO, St, Sp | Data deficient | Yes | ✗ | ✓ | 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 | ✓ | ✓ | Likely |
| Maui's dolphin | *Cephalorynchus hectori maui* | Nationally critical | CD | Endangered | Yes | ✗ | ✗ | Likely * |
| Melon-headed whale | *Peponocephala electra* | Vagrant | SO | Least concern | Yes | ✗ | ✗ | Unlikely |
| Minke Whale | *Balaenoptera acutorostrata* | N/A | N/A | Least concern | No | ✗ | ✗ | Unlikely |

| Common Name | Scientific Name | National status (Baker *et al*, 2016) | Qualifier | IUCN Status www.redlist.org | Species of Concern (DOC. 2013) | DOC stranding database | DOC sightings database | Presence in the Study Area |
|---|---|---|---|---|---|---|---|---|
| New Zealand sea lion | *Phocarctos hookeri* | Nationally critical | RR | Endangered | Yes | ✗ | ✗ | Unlikely |
| New Zealand Fur seal | *Arctocephalus forsteri* | N/A | N/A | Least concern | No | ✗ | ✗ | Likely * |
| Pantropical spotted dolphin | *Stenella attenuata* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Pygmy blue whale | *Balaenoptera musculus brevicauda* | Migrant | TO | Endangered | Yes | ✗ | ✗ | Occasional visitor * |
| Pygmy killer whale | *Feresa attenuata* | Vagrant | DP, SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Pygmy right whale | *Caperea marginata* | Data deficient | SO | Data deficient | Yes | ✓ | ✗ | Possible |
| Pygmy sperm whale | *Kogia breviceps* | Not threatened | DP, SO | Data deficient | Yes | ✓ | ✗ | Likely |
| Risso's dolphin | *Grampus griseus* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Ross seal | *Ommatophoca rossi* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Rough-toothed dolphin | *Steno bredanensis* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| Sei whale | *Balaenoptera borealis* | Migrant | TO | Engandered | Yes | ✗ | ✗ | Unlikely |
| Shepherd's beaked whale | *Tasmacetus shepherdi* | Data deficient | SO | Data deficient | Yes | ✓ | ✗ | Possible |
| Short-finned pilot whale | *Globicephala macrorhynchus* | Migrant | SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Southern bottlenose whale | *Hyperoodon planifrons* | Data deficient | SO | Least concern | Yes | ✗ | ✗ | Unlikely |
| Southern elephant seal | *Mirounga Leonina* | Nationally critical | RR, SO | Least concern | No | ✗ | ✗ | Unlikely |
| Southern Right Whale | *Eubalaena australis* | Nationally vulnerable | RR, SO | Least concern | Yes | ✓ | ✓ | **Likely** |
| Southern right whale dolphin | *Lissodelphis peronii* | Not threatened | DP,SO | Data deficient | Yes | ✗ | ✗ | Unlikely |
| Spade-toothed whale | *Mesoplodon traversii* | Data deficient | SO | Data deficient | No | ✗ | ✗ | Unlikely |
| Spectacled porpoise | *Phocoena dioptrica* | Data deficient | SO | Data deficient | No | ✗ | ✗ | Unlikely |
| Sperm whale | *Physter macrocephalus* | Not threatened | DP, SO | Vulnerable | Yes | ✓ | ✓ | Likely |
| Strap-toothed whale | *Mesoplodon layardii* | Data deficient | SO | Data deficient | Yes | ✓ | ✗ | Possible |
| Striped dolphin | *Stenella coeruleoalba* | Vagrant | SO | Least concern | No | ✗ | ✗ | Unlikely |
| 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 |

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

#### 4.2.4.2 Migration paths through the Operational Area

The annual migration of southern hemisphere baleen whales typically takes them south in the spring to feed in Antarctica and back north to their tropical breeding grounds in autumn-winter (DOC, 2007). Migration paths for humpback, sperm, Bryde's and southern right whales are shown in **Figure 12**. Northern migration routes are fairly well documented whereas the southern migration routes are less well known. There are exceptions to this general migratory pattern and they are described in the individual species accounts below.

The Nikau 3D Seismic Survey is expected to take place in November-December 2016. During this period, the highest densities of most baleen whales are expected at the higher latitude feeding grounds in the Antarctic or the subantarctic. Some southward migration may overlap with survey activities in November; although it is anticipated that the survey will be complete before the northward migration gets underway in late autumn/winter. Overall there is only limited potential for overlap with the migratory behaviours of baleen whales.

**Figure 12 Whale Distribution and Migration Pathways in New Zealand Waters**

**Source:** Te Ara, 2016c.

### 4.2.4.3 Ecological summaries of commonly occurring cetacean species in the Taranaki Basin

#### 4.2.4.3.1 Southern right whale

Southern right whales (*Eubalaena australis*) reach up to 15–18 m in length. This species is particularly vulnerable to ship strikes because of their slow swimming speed of 9 km/hr. This species has a wide vocal repertoire. Southern right whale vocalisations at the subantarctic New Zealand breeding grounds have recently been characterised, with the most frequently recorded vocalisations being 'upcalls', 'pulsive vocalisations' and 'tonal low vocalisations'; with the mean peak frequency of all vocalisations being 264 Hz (range: 43 – 3984 Hz) (Webster *et al.*, 2016).

Southern right whale distribution is seasonal and most individuals spend summer months in latitudes 40–50°S (Oshumi & Kasamatsu, 1986) to feed on plankton (mainly copepods and euphausiids) (Tormosov *et al.*, 1998; Rowantree *et al.*, 2008). Right whales are skim feeders and will swim through swarms of prey with their mouth wide open either at the surface or at depth (Braham & Rice, 1984).

Southern right whales considered as 'nationally vulnerable' (Baker et al., 2016); although recent data indicate that populations are making a recovery (worldwide, southern right whales are regarded by the IUCN as 'of least concern'). Historic whaling activities through the nineteenth century heavily reduced numbers around NZ: with pre-exploitation abundance estimated to be between 28,800 and 47,100 individuals (Jackson et al., 2016). Following the cessation of this whaling activity only 30–40 mature females were thought to remain (Jackson et al., 2016). Today whale numbers remain low, at an estimated 12% of pre-exploitation abundance (Jackson et al., 2016). Due to this reduction, the collection of sighting data and genetic samples for southern right whales was given priority by DOC. The resulting genetic evidence suggested that southern right whales present around mainland New Zealand and the New Zealand subantarctic are part of a single stock (Carroll et *al.*, 2011). It is thought that this single New Zealand population ranges between two winter breeding grounds; the primary breeding ground in the subantarctic, where Port Ross, Auckland Islands is the principal calving area (Rayment *et al.*, 2012), and a secondary breeding ground off mainland New Zealand (Carroll *et al.*, 2011). Southern right whales are the only baleen whale to breed in New Zealand waters, and the coastal waters around mainland New Zealand represent a historic calving ground for this species, with recent evidence suggesting that recolonization of this range is occurring (Patenaude, 2003; Carroll *et al.*, 2011; DOC, 2016a) in association with a strong population recovery (7% per annuam; Carrol *et al.*, 2013). For the period of 1976 to 1991 no cow-calf pairs were recorded around mainland New Zealand; 11 cow-calf pairs were recorded between 1992 and 2002 and 28 cow-calf pairs were recorded between 2003 and 2010 (Carrol *et al.*, 2013). Cow-calf pairs appear to be more prevalent around the North Island compared to the South Island (Carroll *et al.*, 2013).

The DOC sighting data indicates that between January 1970 and January 2016 there were 735 reported sightings of southern right whales in New Zealand's EEZ. The majority of southern right whale sightings around the New Zealand mainland occurred in winter (60%) and spring (22%) with nearly all sightings occurring close to the coast (Patenaude, 2003) (see **Figure 10**). In relation to the Operational Area, the DOC stranding database contains a single historical record of a southern right whale stranded in Taranaki in 1890.

Based on this information, southern right whales could be present in the Operational Area, but sightings typically occur in inshore waters in winter and spring. Although it is possible that individuals could transit offshore through the Operational Area outside of the winter breeding season, but such sightings are uncommon.

### 4.2.4.3.2 Bryde's whale

Bryde's whales inhabit tropical and warm temperate waters. As opposed to other species of baleen whales, they do not migrate (Kato, 2002) and their the latitudinal range is considered to lie between 40°N and 40°S (as summarised in Riekkola, 2013).

Bryde's whales are mainly found in the waters of the North Island, in particular the Hauraki Gulf which is an important breeding area (Baker & Madon 2007; Wiseman *et al.*, 2011). It is thought that this region is used by a sub-population of whales which maintain some level of interaction with a wider (unknown) regional population (Baker *et al.*, 2010). Systematic investigations of this species have been undertaken but were restricted to the Hauraki Gulf and the east coast of Northland. Opportunistic sighting data is available for other regions and confirms that Bryde's whales are occasionally sighted in offshore Taranaki waters (Torres, 2012). No Bryde's whale strandings have been recorded by DOC for Taranaki or Waikato regions.

Whale behaviour in the water column dictates their vulnerability to ship strike and Bryde's whale are known to 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 is a major cause of mortality to Bryde's whales near the Port of Auckland (Constantine *et al.*, 2012). Riekkola (2013) reported that potential effective mitigation measures for this issue include a reduction in vessel speed from 13.2 to 10 knots which could reduce the likelihood of lethal injury in any strike incident from 51% to 16%.

Bryde's whales visit Taranaki waters on the rare occasion, but Taranaki is typically considered to be outside the regional population strong-hold for this species. A single stranding record for this species is present in the DOC strandings database.

### 4.2.4.3.3 Blue whale

Blue whales are the largest animal to ever live, with adults reaching up to 33 m long and weighing up to 180 tonnes (Baker, 1999; Todd, 2014). 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 which has resulted in the generic reporting of 'blue whales' in both stranding and sighting data.

Blue whale detections (both acoustic and visual) have occurred widely in New Zealand waters (Olsen *et al.*, 2013; Miller *et al.*, 2013). Acoustic detections have been most frequent on the west coast of the North Island and the east coast of the South Island. However, this is only a very approximate indication of distribution as blue whales vocalise at a low frequency (average of 0.01 – 0.110 kHz but some calls have a precursor of 0.4 kHz) (McDonald *et al.*, 2001; Miller *et al.*, 2013) which means their calls travel hundreds of kilometres through the water. Their calls can reach levels of up to 188 dB re 1ųPa $m^{-1}$ (Aroyan *et al.*, 2000; Cummings & Thompson, 1971).

Krill (euphasiids) are the primary food source of blue whales. When feeding, blue whales either lunge feed at the surface or dive to average depths of 100 m for up to 50 minutes (Todd, 2014). As blue whales have the highest prey demand of any predator (Rice, 1978; DOC, 2007), large aggregations of food in upwelling areas are crucial to this species survival. Worldwide, blue whales are known to congregate in areas of upwelling as these conditions provide high concentrations of euphausiids (Fiedler *et al.*, 1998; Burtenshaw *et al.*, 2004; Croll *et al.*, 2005; Gill *et al.*, 2011).

A concentration of pygmy blue whales has recently been identified in the South Taranaki Bight, where a research trip in 2014 confirmed that this area is a foraging ground for this subspecies which targets the krill *Nyctiphanes australis* here (Torres *et al.*, 2015). Genetic analysis identified blue whales in the Bight as belonging to a distinct haplotype; hence these individuals may comprise a unique population. The absolute distribution of blue whales changes on a seasonal and year by year basis depending on climatic 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, 2) the first ever aerial footage of blue whale nursing behaviour being documented, and 3) observations of sexual competition ('racing behaviour') among adult males (Torres & Klinck 2016). In addition to these reproductive observations, sightings of blue whales have been made in all months of the year, suggesting a year-round presence of this population in the South Taranaki Bight region (Torres, 2013; 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; however, blue whales are listed as a "Species of Concern" under the Code of Conduct.

As mentioned above, blue whales (particularly pygmy blue whales) utilise the South Taranaki Bight. No specific surveys have occurred for this species in North Taranaki Bight, but it is considered likely that they will be encountered during the Nikau 3D Seismic Survey.

#### 4.2.4.3.4 Fin whale

Fin whales are found in offshore waters throughout the world (Reilly *et al.*, 2013). In summer months, fin whales are distributed between 50–65°S in the South Pacific (Miyashita *et al.*, 1995) and, similarly to other baleen whales, they are thought to move into warmer, lower latitudes in winter to breed, although their breeding grounds are largely unknown.

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) (Mizroch *et al.*, 1984; Shirihai & Jarrett, 2006).

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

Fin whales have been sighted in offshore Taranaki waters (see Torres, 2012) and strandings of this species have been recorded on Taranaki coastlines. Torres (2012) introduced the possibility that they, like blue whales, could also feed on krill aggregations in the South Taranaki Bight. Therefore this species may occasionally visitor the Nikau 3D Seismic Survey Operational Area.

#### 4.2.4.3.5 Humpback whale

Humpback whales undertake the longest migration between feeding and breeding grounds of any mammal (Jackson *et al.*, 2014). As opposed to other baleen whale species, this migration is well documented. The whales feed in Antarctic waters during summer months and migrate north to tropical waters for breeding in the winter. Stock F ('Southwest Pacific Ocean' humpback whale population) migrates 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 movement occurs off the east coast of New Zealand from September to December (NZGeo.com, 2016). Feeding is never observed in New Zealand waters as the whales do not forage during their migrations and survive thanks to their fat reserves accumulated at their southern feeding grounds. On their migrations, humpback whales spend considerable time in coastal regions over the continental shelf (Jefferson *et al.*, 2008).

In order to document humpback whale recovery, DOC conducted annual winter surveys of whales in the Cook Strait from 2004 - 2015 (DOC, 2015a). The number of individuals recorded during these surveys ranged from 15 (in 2006) to 137 (in 2015). Genetic sampling during these surveys has highlighted matches in the population of the wider south pacific region and whales which have been recorded passing through the Cook Strait have also been seen off Australia and New Caledonia.

Male and female humpbacks produce communication calls, but only males emit the long, loud, and complex 'songs' associated with breeding activities. These songs consist of several sounds in a low register, varying in amplitude and frequency, and typically lasting from 10 to 20 minutes (American Cetacean Society, 2014). These songs tend to be between 0.03–8 kHz (Simmonds *et al.*, 2004). In addition to vocalisations, "social sounds" of humpbacks are known to include those generated from surface activities such as breaching and tail-slapping.

Humpback whales are frequently seen in Taranaki waters, particularly between the months of May and August on their northern migration; although they are observed at other times of the year. Therefore it is possible that this species will be and occasional visitor to the Nikau 3D Operational Area.

#### 4.2.4.3.6 Sperm whale

Sperm whales are the largest toothed whale. They are widely distributed throughout the world, generally over the continental slope in waters deeper than 1,000 m. All whales are culturally important to Māori; however, sperm whales in particular are regarded as chiefly figures of the ocean realm and are commonly recognised as taonga (treasure).

Sperm whales feed almost exclusively on squid (Evans & Hindell, 2004; Gaskin & Cawthorn, 1967; Gomez-Villota, 2007). Deep foraging dives (3,000 m) can last up to an hour. No light is available at such depths and the whales rely exclusively on echolocation to locate prey and navigate (Ocean Research Group, 2015). Sperm whales also use clicks as a means of communication, to identify members of a group and to coordinate foraging activities (Andre & Kamminga, 2000). All of these sounds will allow any sperm whales in the proximity to the seismic vessel to be detected by the on-board PAM system.

Photo-identification studies in Kaikoura Canyon have shown a small number of resident male sperm whales are present year round within a few kilometres of the shore (Jaquet *et al.*, 2000). It is estimated that between 60 and 108 whales are present during any one season (Childerhouse *et al.*, 1995), but that as few as four to five sperm whales are present on average per day (Sagnol *et al.*, 2015). However, this is the extent of detailed population studies of this species in New Zealand waters. Torres (2012) reported that sperm whale sightings in the South Taranaki Bight/Greater Cook Strait region typically occurred in deep offshore water and were limited to the summer months. A reasonable number of sperm whale strandings have occurred along the Taranaki and Waikato coastlines. Further to these, there are two sightings of sperm whales recorded in the DOC sightings database for the Operational Area. Hence, sperm whales are likely to be encountered in deeper waters during the Nikau 3D Seismic Survey.

#### 4.2.4.3.7 Beaked whales

Very little is known about the distribution of beaked whales within New Zealand's EEZ. Their preference for deep offshore waters and their elusive behaviour at sea contribute to this paucity of knowledge (Baker, 1999). Twelve species of beaked whales are present in New Zealand; however, it is difficult to identify specific habitat types and behaviour for each individual species, as most of the information comes from stranded whales, which in some cases provides the only knowledge that they exist within New Zealand waters. Beaked whales are mostly found in small groups in cool, temperate waters with a preference for pelagic deep ocean waters or continental slope habitats at depths down to 3,000 m. They are deep divers and feed predominately on deep-water squid and fish species.

Of the twelve species known to New Zealand waters, five are represented in the stranding record for Taranaki and Waikato (Andrew's beaked whale, Cuvier's beaked whale, Gray's beaked whale, Shepherd's beaked whale, Strap-toothed whale). These contribute to a total of 10 beaked whale stranding events in the region.

#### 4.2.4.3.8 Hector's dolphin (South Island and Māui)

The Hector's dolphin is one of the world's smallest cetaceans (1.2-1.5 m). Hector's dolphins are split into two subspecies: the South Island Hector's dolphin and the Māui dolphin. Both subspecies have seen a dramatic decline in the last 40 years caused by bycatch in coastal fisheries (Currey *et al.*, 2012). The Māui 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. In general, Māui dolphins are present on the west coast of the North Island, with South Island Hector's dolphins being present around the South Island. Occasional sightings off the south and east coasts of the North Island are unverified, but are most likely South Island Hector's dolphins. Despite the genetic distinction of subspecies, there is no evidence to suggest that the ecology of the two is substantially different (Torres, 2012).

Māui dolphins are restricted in distribution to 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) (**Figure 13**). The most recent population estimate for Māui dolphins is 55 individuals aged one year and over (95% CI = 48–69) with an estimated population decline of 2.8% per annum (Hamner *et al.*, 2012). Māui dolphins are thought to occur in very low densities in Taranaki waters (Currey *et al*, 2012). The capture of a Māui dolphin in a commercial set net off Cape Egmont in January 2012 confirms their presence in coastal Taranaki waters (DOC, 2016b).

There is some transfer of individuals between populations, with South Island Hector's dolphins having been genetically identified off the west coast of the North Island (Hamner *et al.*, 2012). It is unknown where dolphins that do make this journey between the North and South Islands chose to cross; it has been hypothesised that dolphins could use shallow waters in the South Taranaki Bight to make this crossing, as opposed to the deeper waters of Cook Strait (Hamner *et al.*, 2013).

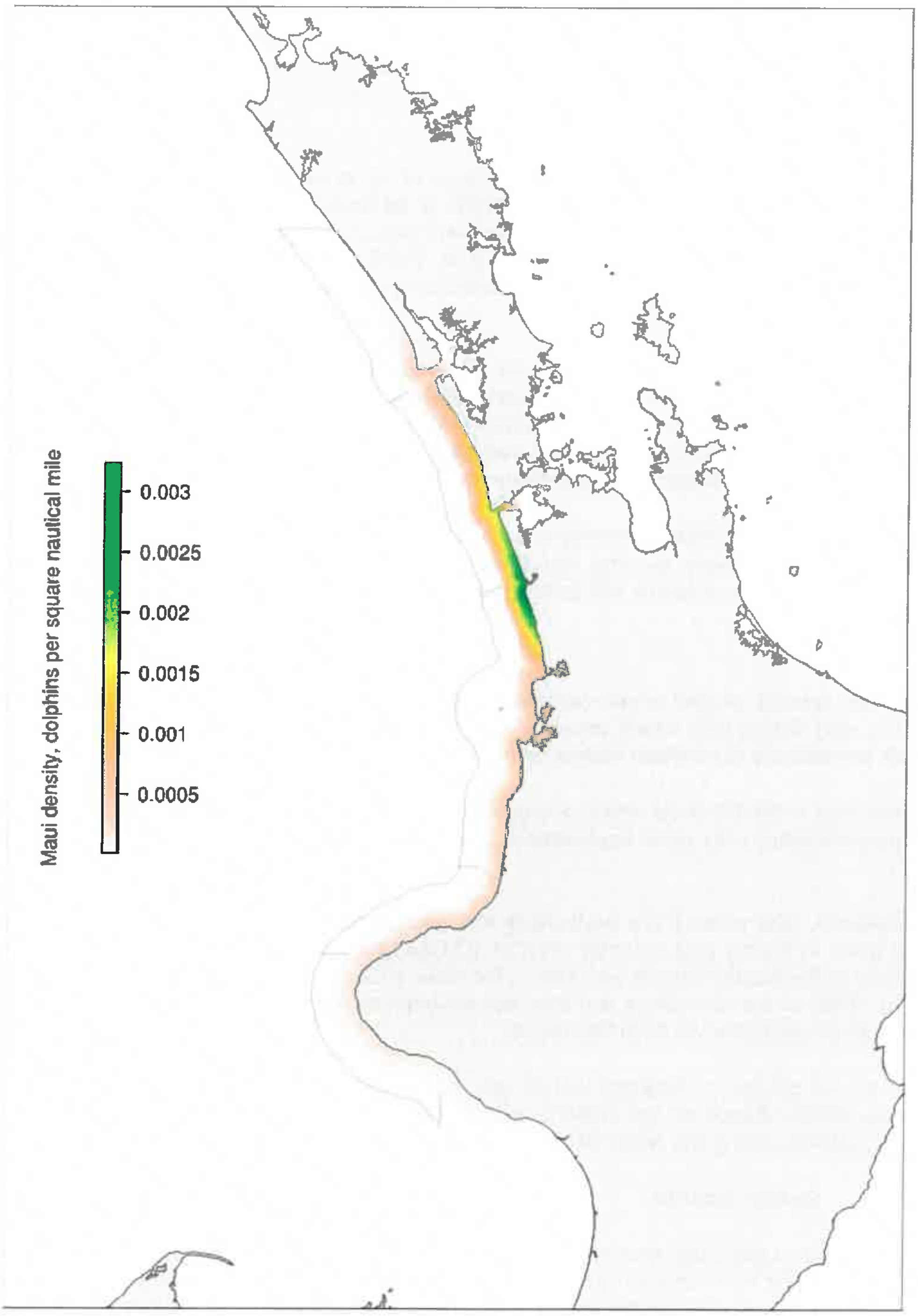
Systematic surveys provide evidence that both subspecies have coastal distributions with Maui's dolphins being observed out to 7 Nm offshore (Scali, 2006) and South Island Hector's dolphins out to 20 Nm offshore (MacKenzie & Clement, 2014). Unverified sightings have occasionally occurred further offshore (out to 24 Nm) (Du Fresne, 2010). Offshore sightings for both subspecies are more common in winter months, and distribution is thought to be largely constrained within the 100 m isobath (Slooten *et al.*, 2006; Du Fresne, 2010).

Both subspecies prey upon a range of small fish and crustacean species. They use echolocation (at frequencies of around 129 kHz) during foraging dives to locate prey (Kyhn *et al.*, 2009). Vocalisations are also used for communication in this species.

Despite their low densities in the Operational Area, the Māui dolphin subspecies is likely to occur in the Nikau 3D Operational Area.

The West Coast North Island Marine Mammal Sanctuary is described in **Section 4.3.3**. This sanctuary was established in 2008 to protect Maui dolphins from fishing and other anthropogenic pressures. Seismic surveys can occur within the sanctuary so long as they are conducted in accordance with Section 5 of the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008; these restrictions are different to those outlined in the Code of Conduct; sometimes more restrictive, sometimes less. The Nikau 3D Seismic Survey does not overlap with the sanctuary.

**Figure 13 Maui dolphin distribution**



Source: Currey *et al.*, 2012

#### 4.2.4.3.9 Common dolphin

There are two species of common dolphin worldwide: the short-beaked common dolphin and the long-beaked common dolphin. The short-beaked common dolphin can be found along the coast of both islands of New Zealand (Berkenbusch *et al.*, 2013). Despite the absence of a population estimate for New Zealand waters, high rates of genetic diversity are consistent with a large population (Stockin *et al.*, 2013).

This social species is known to aggregate in groups of up to several thousand individuals. In New Zealand, they have been recorded in water depths of between 6 and 141 m (Constantine & Baker, 1997). Jack mackerel, anchovy, and arrow squid have been found to be the predominant prey species for common dolphins in New Zealand (Meynier *et al.*, 2008). Further studies of the stomach contents of common dolphins in New Zealand have indicated an onshore-offshore diel migration (Meynier *et al.*, 2008).

Common dolphins rely on echolocation to feed. Vocalisations known as 'click trains' are produced in order to locate prey and navigate. Other vocalisations recorded in this species include whistles and burst pulse calls which are both forms of communication. Studies of whistle characteristics of common dolphins in the Hauraki Gulf have indicated that average frequency and length of these vocalisations are 10 – 14 kHz and 0.27 seconds, respectively (Petrella, 2012).

Common dolphins are the most frequently encountered species in Taranaki waters (Torres, 2012). Most sightings occur over summer months, but this seasonality is likely a reflection of observational bias (Torres, 2012). Common dolphins will certainly be encountered during the Nikau 3D Seismic Survey.

#### 4.2.4.3.10 Pilot whales

There are two species of pilot whale worldwide: the short-finned pilot whale and the long-finned pilot whale. The long-finned pilot whale occurs throughout New Zealand waters whereas the short-finned pilot whale is restricted to northern waters as it prefers a warmer subtropical climate.

Pilot whales tend to feed in deep waters along shelf breaks. In New Zealand, it has been found that this species predominantly prey upon cephalopods such as arrow squid and common octopus (Beatson *et al.*, 2007).

In New Zealand, pilot whales are particularly well known for their propensity to strand. Strandings generally peak in spring and summer months (O'Callaghan *et al.*, 2001) and Farewell Spit, at the northwest tip of the South Island is well known for mass stranding incidents (28 incidents between 1937 and 2014). Pilot whale strandings are also not uncommon along the Taranaki coast; however, large mass strandings are unknown from this region.

Sightings of pilot whales in Taranaki waters are reasonably common with most occurring in summer (see Torres, 2012). Based on the sighting and stranding data, it is likely that long-finned pilot whales will be encountered during the Nikau 3D Seismic Survey.

#### 4.2.4.3.11 Dusky dolphin

The dusky dolphin is generally encountered in coastal waters (less than 2,000 m) above the continental shelf and slope. The New Zealand population is now considered to be an endemic subspecies that is yet to be named (Society for Marine Mammalogy Committee on Taxonomy, 2014; as cited in Baker *at al.*, 2016). This subspecies can be found year round in the waters of the South Island and lower North Island (Wursig *et al.*, 2007; Berkenbusch *et al.*, 2013).

Two main subpopulations are known to exist in the South Island. The first resides in Admiralty Bay from April to July. The second is located in the vicinity of Kaikoura and counts approximatively 12,000 individuals, with approximately 2,000 individuals present at any one time (Markowitz *et al.*, 2004).

Although the specifics of dusky dolphin movement are yet to be elucidated, photo-ID studies have indicated that this species is capable of large scale movements (up to 1,000 km between locations around the South Island). These movements are thought to have a significant seasonal component whereby this species would spend more time offshore during the winter months (Wursig *et al.*, 2007).

Dusky dolphin prey species include 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.

Few sighting records of dusky dolphins have been made in Taranaki waters (see Torres, 2012). This information indicates that this species may use waters within the Operational Area, but it is typically found to the south of the Operational Area in more sheltered coastal waters.

#### 4.2.4.3.12 Killer whale

Worldwide, killer whales have an extensive range spanning from equatorial to polar waters. Four morphotypes of this species are recognised *Orcinus orca*, *Orcinus sp*. Type B, *Orcinus sp*. Type C and *Orcinus sp*. Type D (Baker *et al.*, 2016).

Although, all morphotypes are thought to visit New Zealand waters, the majority of New Zealand killer whale sightings are thought to be *Orcinus orca* and have occurred in all coastal regions of New Zealand including the North Taranaki Bight (Visser, 2000; Visser, 2007).

Photo-identification studies conducted in 1997 produced a New Zealand population estimate of 115 individuals (95% CI 65–167) (Visser, 2000). As a result of this small population size, killer whales in New Zealand have been classified as 'nationally critical' by the New Zealand Threat Classification System.

Around New Zealand, killer whales are highly mobile, travelling on average 100–150 km per day (Visser, 2000) to feed opportunistically. Torres (2012) found sightings in the South Taranaki Bight to be relatively evenly distributed through time; although limited information exists about the seasonality of this species in North Taranaki waters.

As in other delphinid species, killer whales are known use sound to both communicate (whistles) and hunt (echolocation). Variations in these whistles and echolocation pulses have been noted between pods (referred to as dialects) (Deecke *et al.*, 2000) and depending on target prey species (Barrett-Lennard *et al.*, 1996).

Given their wide ranging, highly mobile nature, it is likely that this species frequently passes through waters of the Operational Area, but sighting and stranding data indicates that this area is not of particular ecological significance. The mobility of this species and their typically opportunistic foraging behaviour indicates that killer whales can readily move between areas to maximise foraging opportunities and avoid disturbance.

It is likely that killer whales pass through the Operational Area from time to time and they are likely to be present during the Nikau 3D Seismic Survey.

### 4.2.4.4 Pygmy right whale

The pygmy right whale (*Caperea marginata*) is the smallest of the baleen whales (Reilly *et al.*, 2008; Baker, 1999). Little is known of the life history of this species and it is known as the least studied baleen species in the southern hemisphere (Shirihai, 2006). It is thought to feed predominantly on zooplankton such as calanoid copepods and euphausiids (Kemper, 2002). Available information on the acoustic repertoire of the species is limited to data collected during a single recording on a juvenile in Australia. Analysis of the recording identified at least on type of call which was described as a short thump-like pulse with a downsweep in frequency and decaying amplitude (Dawbin & Cato, 1992).

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

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

#### 4.2.4.5 Pygmy sperm whale

Little is known of the pygmy sperm whale (*Kogia breviceps*). Stranded individuals have proffered some information on diet preferences and acoustics. Based on these data it is understood that this species primarily feeds on cephalopods, with a minor component of fish and crustaceans (Beatson, 2007). In terms of acoustics, the gathered information has indicated that the species emits click trains between 60 kHz and 200 kHz (Marten, 2000).

This species occurs in deep offshore water (beyond the edge of the continental shelf) in temperate and tropical waters (Taylor *et al.*, 2012). Strandings of this species are relatively common in New Zealand waters, with two strandings of relevance to the Operational Area. Stranding events along the New Zealand coastline are largely of single animals; however, the presence of stranded mother/calf pairs is noteworthy from January to April (Baker, 1999). This indicates a summer breeding season for this species in New Zealand waters.

### 4.2.5 Pinnipeds

Nine species of pinnipeds are known from New Zealand waters. Of these only the New Zealand fur seal is predicted to occur in the Operational Area.

#### 4.2.5.1 New Zealand Fur Seal

The New Zealand fur seal occurs exclusively in New Zealand and Australia. Occurrence in New Zealand is widespread around the entire mainland and offshore islands. Since the cessation of commercial sealing, the species has been recolonising areas of its historic range. Population size has increased and breeding distribution has expanded towards the north (Lalas & Bradshaw, 2001). Despite this, breeding colonies are still mainly located in the South Island. Although a total abundance for the species is not known, estimates lie in the region of 100,000 individuals (Harcourt, 2001).

Foraging often occurs both inshore and offshore along the shelf break with some seasonal variation in location (Harcourt et al, 2002; Mattlin et al, 1998). 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) in dives which last for up to 12 minutes (~ 200 m) (Mattlin *et al.*, 1998)

New Zealand fur seals breed between mid-November to mid-January with a peak in pupping in mid-December (Crawley & Wilson, 1976). During 300 days after giving birth, female seals will alternate between foraging trips and visits to the rookery to feed their young (Boren, 2005). The closest breeding colony to the Operational Area is the Sugar Loaf Islands Marine Protected Area, just off New Plymouth. Specific breeding locations include Waikaranga (Seal Rock), Moturoa and Whareumu (Lion Rock). These breeding locations lie 20–25 km to the southeast of the Operational Area.

New Zealand fur seals are consistently observed in North Taranaki Bight waters and often congregate at oil and gas facilities. This species will certainly be seen during the Nikau 3D Seismic Survey.

### 4.2.6 Marine Reptiles

There are seven species of marine reptiles known to occur in New Zealand waters: the logger head turtle, the green turtle, the hawksbill turtle, the olive ridley turtle, the leatherback turtle, the yellow-bellied sea snake and the banded sea snake (DOC, 2016). 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.

Marine reptiles do occasionally visit waters off central New Zealand, although mainly during summer months when the warmer currents push down the western side of New Zealand. Loggerhead turtles, olive ridley turtles, leatherback turtles, and yellow-bellied sea snakes have been observed in the vicinity of the Operational Area (DOC, 2016c); however, they are rare visitors and are unlikely to be present during the Nikau 3D Seismic Survey.

### 4.2.7 Seabirds

Ninety-six species of seabird can be found in New Zealand (Taylor, 2000). These include albatross, cormorants/shags, fulmars, petrels, prions, shearwaters, terns, gulls, penguins, and skuas. Of these, 84 species breed in New Zealand (MacDiarmid *et al.*, 2011) and at least one-third are endemic (DOC, 2016d).

Although the importance of the North Taranaki and southwest Waikato regions to seabirds is largely unknown, these regions are visited by a large diversity of seabirds that either pass through (e.g. during migrations or foraging trips) or use the area as a more permanent breeding and roosting location. Many of the species present have coastal distributions, such a penguins, shags, gulls, and terns. However, other pelagic species such as albatrosses, shearwaters, and petrels utilise offshore waters. In addition, gulls and terns can extend their distribution to more offshore areas.

Various references, e.g. NABIS (2016), Scofield & Stephenson (2013), Robertson *et al.* (2013), and NZ Birds Online (2016) 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 9.**

A number of sites along the North Taranaki/Southwest Waikato coast are of breeding value to seabirds. The locations of known seabird breeding sites are presented in **Figure 14.**

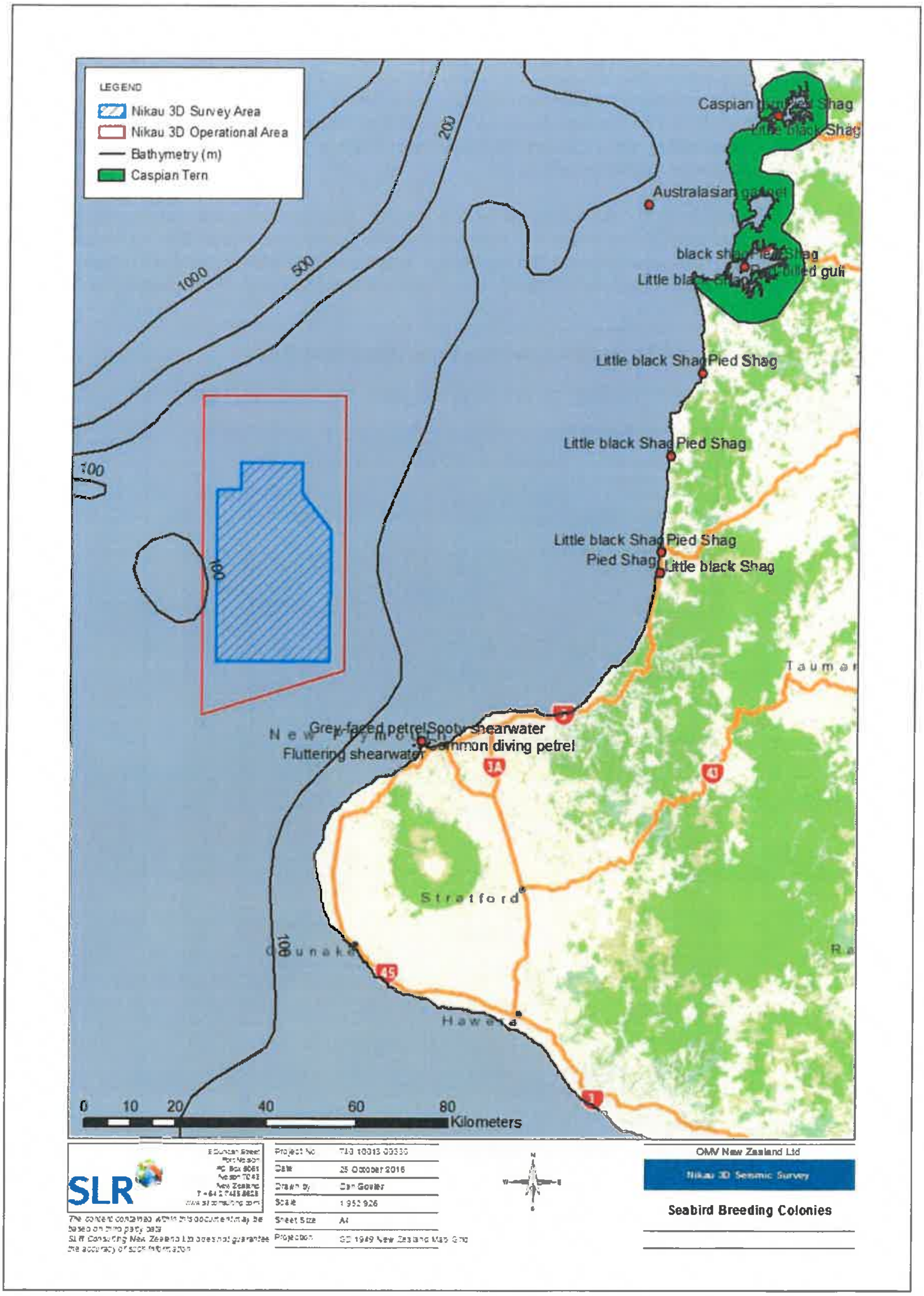
**Table 9 Seabird Species Potentially Present in the Operational Area**

| **Common Name** | **Scientific Name** | **Breeding season** | **Breeds Adjacent to Operation Area** | **IUCN Status** www.redlist.org | **NZ Threat Status** Robertson *et al*, 2013 |
|---|---|---|---|---|---|
| Antipodean Albatross | *Diomedea antipodensis antipodensis* | Eggs laid Jan/Feb | × | Not assessed | Nationally Critical |
| Back-billed gull | *Larus bulleri* | Aug – Mar | × | Endangered | Nationally Critical |
| Fairy tern | *Sternula nereis* | Oct – Feb | × | Vulnerable | Nationally Critical |
| Gibson's albatross | *Diomedea antipodensis gibsoni* | All year | × | Not assessed | Nationally Critical |
| Salvin's mollymawk | *Thalassarche salvini* | Sep – Apr | × | Vulnerable | Nationally Critical |
| Black-fronted tern | *Chlidonias albostriatus* | Oct – Jan | × | Endangered | Nationally Endangered |
| Black petrel | *Procellaria parkinsoni* | Oct – Jul | × | Vulnerable | Nationally Vulnerable |
| Caspian tern | *Hydroprogne caspia* | Sep – Jan | ✓ | Least Concern | Nationally Vulnerable |
| Flesh-footed shearwater | *Puffinus carneipes* | Sep – May | × | Least Concern | Nationally Vulnerable |
| Grey-headed albatross | *Thalassarche chrysostoma* | Sep – May | × | Endangered | Nationally Vulnerable |
| Pied shag | *Phalacrocorax varius varius* | All year | Possible | Not assessed | Nationally Vulnerable |
| Red billed gull | *Larus novaehollandiae scopulinus* | Sep – Jan | Possible | Least Concern | Nationally Vulnerable |
| Hutton's shearwater | *Puffinus huttoni* | Oct – Mar | × | Endangered | Declining |
| Little penguin | *Edyptula minor* | Jul – Feb | ✓ | Least Concern | Declining |
| Sooty shearwater | *Puffinus griseus* | Nov – May | ✓ | Near Threatened | Declining |
| White-capped mollymawk | *Thalassarche cauta* | Nov – Aug | × | Not assessed | Declining |
| White-chinned petrel | *Procellaria aequinoctialis* | Nov – May | × | Vulnerable | Declining |
| White-fronted tern | *Sterna striata striata* | Oct – Jan | ✓ | Least Concern | Declining |
| Little shearwater | *Puffinus assimilis* | Apr – Nov | × | Vulnerable | Recovering |
| Broad-billed prion | *Pachyptila vittata* | Aug – Jan | × | Least Concern | Relict |
| Cook's petrel | *Pterodroma cookii* | Sep - Apr | × | Vulnerable | Relict |
| Fairy prion | *Pachyptila turtur* | Oct – Feb | ✓ | Least Concern | Relict |
| Fluttering shearwater | *Puffinus gavia* | Aug – Jan | × | Least Concern | Relict |
| Grey-backed storm petrel | *Garrodia nereis* | Sep – Apr | × | Least Concern | Relict |

| | | | | | |
|---|---|---|---|---|---|
| Mottled petrel | *Pterodroma inexpectata* | Dec – May | × | Near Threatened | Relict |
| Northern diving petrel | *Pelecanoides urinatrix urinatrix* | Aug – Dec | × | Not assessed | Relict |
| Wedge-tailed shearwater | *Puffinus pacificus* | Oct – May | × | Least Concern | Relict |
| White-faced storm petrel | *Pelagodroma marina* | Oct – Apr | Possible | Least Concern | Relict |
| Antarctic Prion | *Pachyptila desolata* | Dec – Apr | × | Least Concern | Naturally Uncommon |
| Black shag | *Phalacrocorax carbo* | All year | ✓ | Least Concern | Naturally Uncommon |
| Brown skua | *Catharacta anterctica lonnbergi* | Sep – Feb | × | Least Concern | Naturally Uncommon |
| Buller's mollymawk | *Thalassarche bulleri* | Oct – Jun | × | Not assessed | Naturally Uncommon |
| Buller's shearwater | *Puffinus bulleri* | Sep – May | × | Vulnerable | Naturally Uncommon |
| Campbell black-browed mollymawk | *Thalassarche impavida* | Aug – May | × | Vulnerable | Naturally Uncommon |
| Fulmar prion | *Pachyptila crassirostris* | Oct – Feb | × | Least Concern | Naturally Uncommon |
| Grey petrel | *Procellaria cinerea* | Apr – Nov | × | Near Threatened | Naturally Uncommon |
| Little black shag | *Phalacrocorax sulcirostris* | Oct – Dec | ✓ | Least Concern | Naturally Uncommon |
| Northern giant petrel | *Macronectes halli* | Aug – Feb | × | Least Concern | Naturally Uncommon |
| Northern royal albatross | *Diomedea sandfordi* | Eggs laid Oct/Nov | × | Endangered | Naturally Uncommon |
| Southern royal albatross | *Diomedea epomophora* | Eggs laid Nov/Dec | × | Vulnerable | Naturally Uncommon |
| Westland petrel | *Procellaria westlandica* | Mar - Dec | × | Vulnerable | Naturally Uncommon |
| Arctic skua | *Stercorarius parasiticus* | Does not breed in NZ | | Least Concern | Migrant |
| Arctic tern | *Sterna paradisaea* | Does not breed in NZ | | Least Concern | Migrant |
| Blue petrel | *Halobaena caerulea* | Does not breed in NZ | | Least Concern | Migrant |
| Cape pigeon | *Daption capense* | Nov – Feb | Possible | Least Concern | Migrant |
| Little tern | *Sternula albifrons* | Does not breed in NZ | | Least Concern | Migrant |
| Medium-billed prion | *Pachyptila salvini* | Does not breed in NZ | | Least Concern | Migrant |
| Short-tailed shearwater | *Puffinus tenuirostris* | Does not breed in NZ | | Least Concern | Migrant |
| Southern giant petrel | *Macronectes giganteus* | Does not breed in NZ | | Least Concern | Migrant |
| Thin-billed prion | *Pachyptila belcheri* | Does not breed in NZ | | Least Concern | Migrant |

| | | | | | |
|---|---|---|---|---|---|
| Wandering/snowy albatross | *Diomedea exulans* | Does not breed in NZ | | Vulnerable | Migrant |
| Wilson's storm petrel | *Oceanites oceanicus* | Does not breed in NZ | | Least Concern | Migrant |
| White winged black tern | *Childonias leucopterus* | Does not breed in NZ | | Least Concern | Migrant |
| Australasian gannet | *Morus serrator* | Aug – Mar | ✓ | Least Concern | Not Threatened |
| Black browed mollymawk | *Thalassarche melanophys* | Sep – May | × | Near Threatened | Coloniser |
| Grey faced petrel | *Pterodroma macroptera gouldi* | Mar – Jan | ✓ | Least Concern | Not Threatened |
| Indian ocean yellow-nosed mollymawk | *Thalassarche carteri* | Eggs laid Sep/Oct | × | Endangered | Coloniser |
| Little shag | *Phalacrocorax melanoleucos brevirostris* | Aug – Mar | ✓ | Not assessed | Not Threatened |
| Southern black-backed gull | *Larus dominicanus dominicanus* | Sep – Mar | ✓ | Not assessed | Not Threatened |
| White-headed petrel | *Pterodroma lessonii* | Nov – Jun | × | Least Concern | Not Threatened |

**Figure 14 Seabird Breeding Colonies in the Vicinity of the Operational Area**



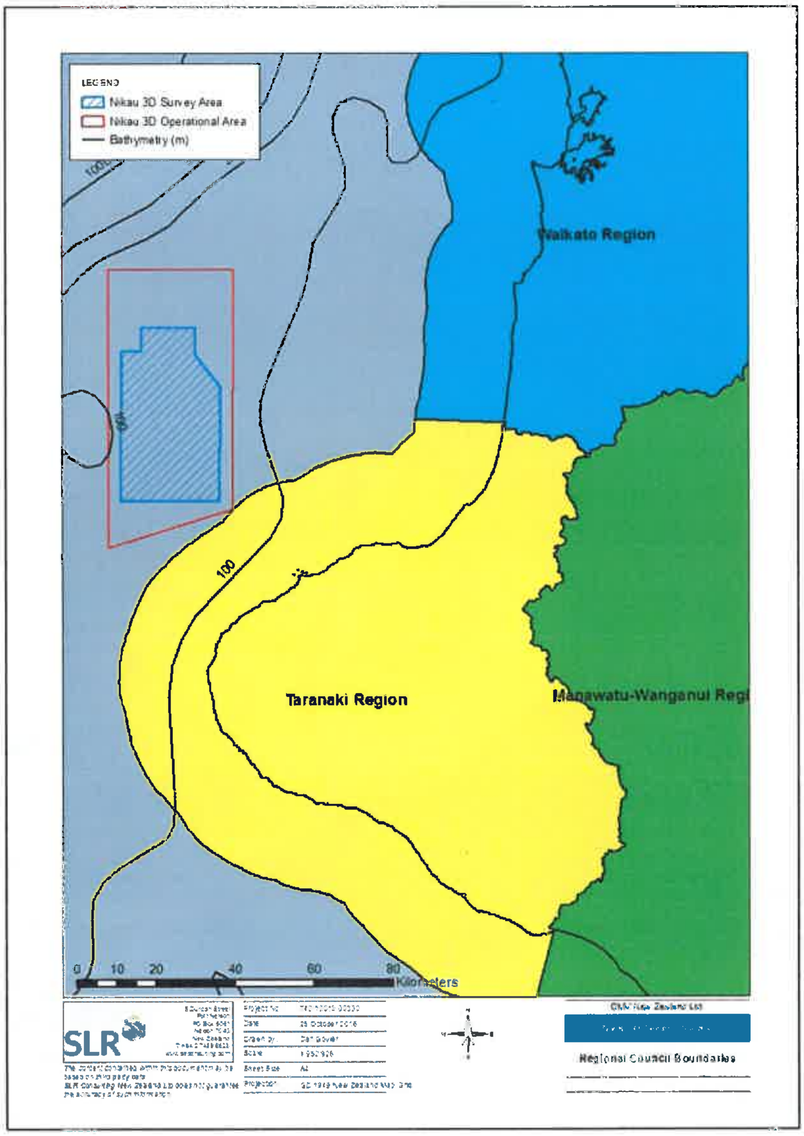
## 4.3 Coastal and Marine Conservation

### 4.3.1 Regional Coastal Environment

The Operational Area extends from New Plymouth in the south to Waikawau (Waikato) in the north. It occurs offshore and does not enter the Coastal Marine Area (CMA). The CMA inshore of the Operational Area is under the jurisdiction of Waikato Regional Council and Taranaki Regional Council (see **Figure 15**). Within their jurisdiction, each council has identified a range of different habitats and areas of significance that are unique to that region.

The following information is a brief overview of the coastal environment within each region and a description of the significant areas that are of relevance to the Operational Area. It is important to note that no spatial overlap will occur between the significant areas and the Operational Area; however, they are included here to provide a coastal context in the extremely unlikely event of an oil spill (see **Section 5.2.3**).

**Figure 15: Regional Council Boundaries in Relation to the Operational Area**



#### 4.3.1.1 West Waikato Coast

The Waikato region is the fourth largest in New Zealand. It covers a section of the east and west coast of the North Island, however, only the south-west Waikato coast is of relevance to the Operational Area.

The south-western stretch of coastline in the Waikato region is considered to be a high energy coastline. It contains habitats such as beaches and sand dune predominately characterised by black sand, exposed tidal flats, gravel, cobble and boulder beaches, eroding wavecut platforms, and estuarine environments in the large sheltered harbours (WRC, 2005).

Waikato Regional Council have identified a number of 'Areas of Significant Conservation Value' based on criteria including Maori cultural values, presence of protected areas, wetlands, estuaries, coastal lagoons, important habitats and ecosystems, and scenic and historic values (WRC, 2005). The Areas of Significant Conservation Value of relevance to the Operational Area (i.e. those on the west coast, south of Kawhia Harbour) and their associated values are provided in **Table 10**.

**Table 10 Areas of Significant Conservation Value in South-West Waikato**

| Site | Values |
|---|---|
| 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. |
| 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. |
| 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. |

#### 4.3.1.2 Taranaki Coast

The long coastline of the Taranaki region encompasses a range of habitats including rocky shores and cliffs, sandy beaches, subtidal reefs, river mouths, and estuaries. The intertidal reefs along this coastline generally have a relatively lower species diversity and abundance than similar systems around New Zealand. The high energy coastline has abrasive and turbulent shoreline conditions, high turbidity, suspended silt, and sand inundation (TRC, 2009a).

Taranaki Regional Council has identified a number of sites as 'Areas of Outstanding Coastal Value' (AOCV). These areas (also referred to as Coastal Management Areas 'A') have been identified within the Regional Coastal Plan for Taranaki (1997) for the purpose of promoting sustainable management of the coastal environment and are to be managed in a way that gives priority to avoiding adverse effects. Sites are considered an AOCV based on values such as the existence of outstanding natural features and landscapes, significant habitats of marine life of birdlife, and significant unmodified natural character (TRC, 1997).

The AOCVs that are of relevance to the Operational Area (i.e. north of Cape Egmont) are briefly described in **Table 11**.

**Table 11 Areas of Outstanding Coastal Value in Northern Taranaki**

| Site | Values |
|---|---|
| Pariokariwa Point to Waihi Stream | This stretch of coastline includes Oporurapa Island which provides haul out sites for New Zealand fur seals and roosting areas for seabirds. The offshore reef connected to the island contains abundant marine life. There are outstanding natural landscapes further along the coast at White Cliffs. The shipwreck 'Alexandra' is located in shallow waters offshore of White Cliffs. Fluttering shearwaters breed on the cliffs and blue penguins burrow near the stream mouths. There are outstanding natural features and landscape at Tongaporutu, particularly offshore stacks, cliffs, and caves. Grey-faced petrels breed on offshore stacks. Tongaportutu Estuary contains abundant and diverse shellfish. The CMA surrounds Te Kawau Pa Historic Reserve and the Mohakatino Beach Conservation Area is adjacent to the Mohakatino Estuary. Australasian bittern and Caspian tern roost on the sandflats and wetland adjacent to this Estuary which also supports whitebait, flounder and shellfish. |
| Mimi Estuary | The Mimi Estuary contains tidal mudflats, saltmarsh, and sand dune habitat which are uncommon in northern Taranaki. It provides habitat for migratory and wading birds and a whitebait spawning area in the upper estuary. The estuary is a feeding ground for snapper and trevally and a nursery area for juvenile marine species such as flounder. The estuary is a periodic breeding site for blue penguin. |
| Sugar Loaf Islands/Nga Motu Marine Protected Area | The Sugar Loaf Islands are the oldest volcanic formations in the Taranaki region. The islands provide important nesting habitat for 27,000 seabirds per year and contain vulnerable indigenous plant species. Moturoa and Motumaganga Islands are free of exotic predators. The Protected Area includes breeding ground for New Zealand fur seals. The waters of the Protected Area contain a diverse range of underwater habitats and diverse and abundant marine life. Marine urupa (burial grounds) of Nagti-te-whiti hapu are located at Motukuku Reef. |

In addition to the AOCVs in **Table 11**, Taranaki Regional Council, New Plymouth District Council, South Taranaki District Council and DOC have developed a list of coastal areas of local or regional significance in the Taranaki region. These areas are considered significant due to their amenity, recreational, cultural/historical and/or ecological/scientific values (TRC, 2004). **Table 12** provides the sites of relevance to the Operational Area.

**Table 12 Coastal Areas of Local or Regional Significance in Northern Taranaki: Values**

| Site | 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 | Moderate |
| Pariokariwa Reef & Opourapa Island | High | Moderate | High | Moderate |
| Pukearuhe | Moderate | Moderate | High | NA |
| Waiiti Beach | High | High | High | High |

| | | | | |
|---|---|---|---|---|
| Mimi Estuary | High | Moderate | High | High |
| Urenui Estuary & Beach | High | High | High | High |
| Onaero Estuary & Beach | High | High | High | Moderate |
| Buchanans Bay | Moderate | Moderate | High | High |
| Motunui Beach | Moderate | Moderate | High | NA |
| Waitara Estuary | High | Moderate | High | Moderate |
| Waitara, Waiongana & Airedale Reefs | High | High | Moderate | Moderate |
| Waiongana Estuary | High | Moderate | High | High |
| Bell Block Beach & Waipu Lagoons | High | High | High | High |
| Waiwhakaiho Estuary | High | High | High | Moderate |
| Fitzroy Beach | High | High | NA | NA |
| East End Beach | High | High | High | NA |
| New Plymouth Foreshore | High | High | NA | NA |
| Kaweroa Park | High | High | NA | NA |
| Ngamotu Beach | High | High | High | Moderate |
| Sugar Loaf Islands Marine Protected Area | High | High | High | High |

From the table above it is noteworthy that Epiha Reef is the most extensive intertidal reef system in north Taranaki, Mohakatino Estuary one of the least modified estuaries in north Taranaki and Te Puia is one of the few remaining natural areas of uplifted marine terrace.

### 4.3.2 New Zealand Marine Environmental Classification

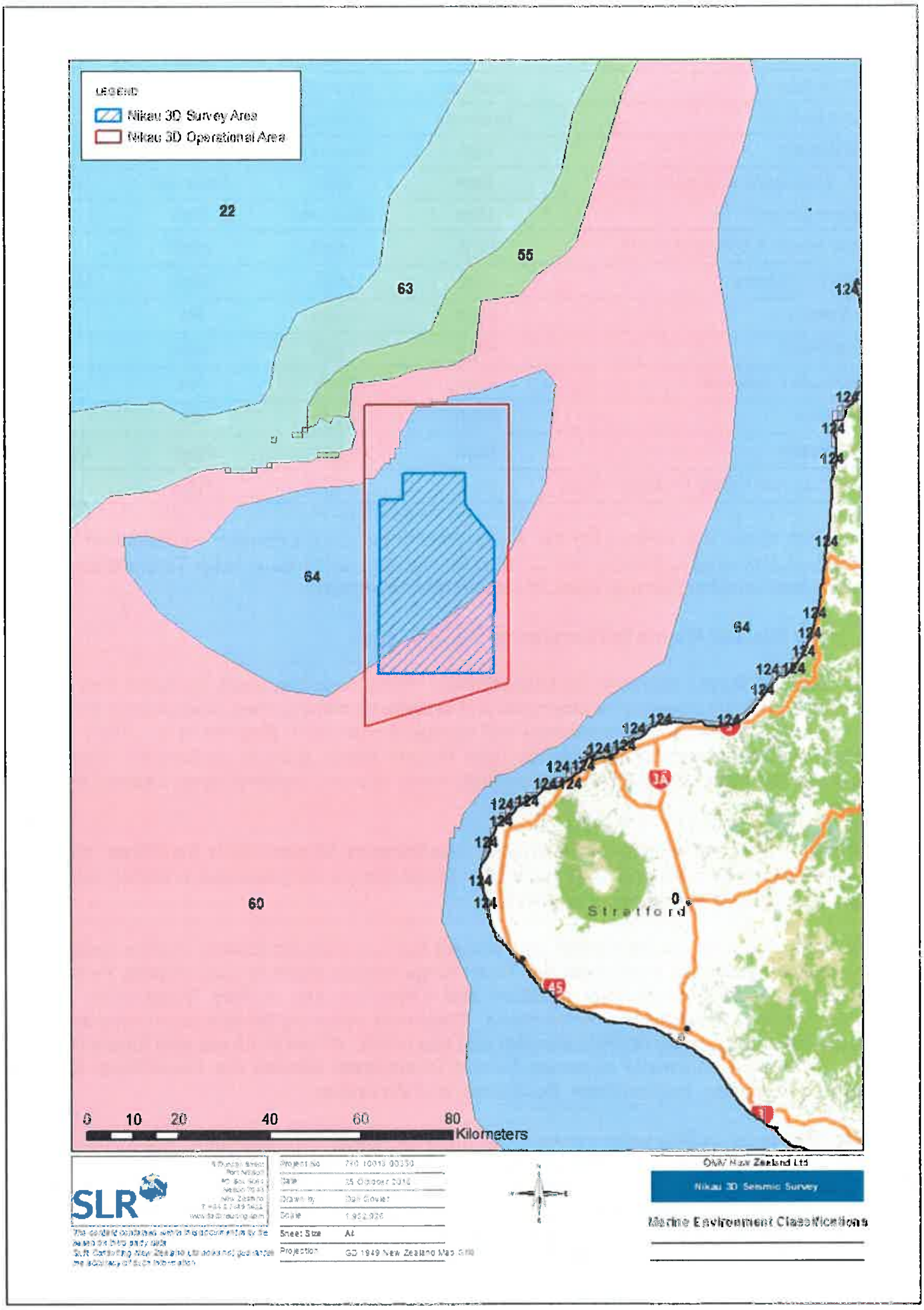
The New Zealand Marine Environment Classification covers New Zealand's Territorial Sea and EEZ and provides a spatial framework for structures and systematic management. Geographic domains are divided into units with similar environmental and biological characters (Snelder *et al.*, 2005). Physical and biological factors used to characterise units include depth, primary productivity, characteristic species, solar radiation, sea surface temperature, wave, current, sediment type, seabed slope, and curvature.

Under the New Zealand Marine Environmental Classification 20-class level the Nikau 3D Seismic Survey falls within groups 60 and 64 (**Figure 16**). These groups are described in further detail below, following the definitions in Snelder *et al.* (2005).

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

**Class 64:** represents shallow waters (mean = 38 m) in the South Taranaki Bight. 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 concentrations in this class. Some of the most 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**



### 4.3.3 Protected Natural Areas

Protected Natural Areas are put in place for the conservation of biodiversity. They receive varying degrees of protection as a result of their recognised natural values. Protected Natural Areas are managed under six main pieces of legislation; the Conservation Act 1987, National Parks Act 1980, Reserves Act 1977, Wildlife Act 1953, Marine Reserves Act 1971, and the Marine Mammals Protection Act 1978.

Of relevance to the Operational Area are the Ngā Motu/Sugar Loaf Islands Marine Protected Area, the West Coast North Island Marine Mammal Sanctuary, and the following marine reserves: Tapuae, and Parininihi (**Figure 17**).

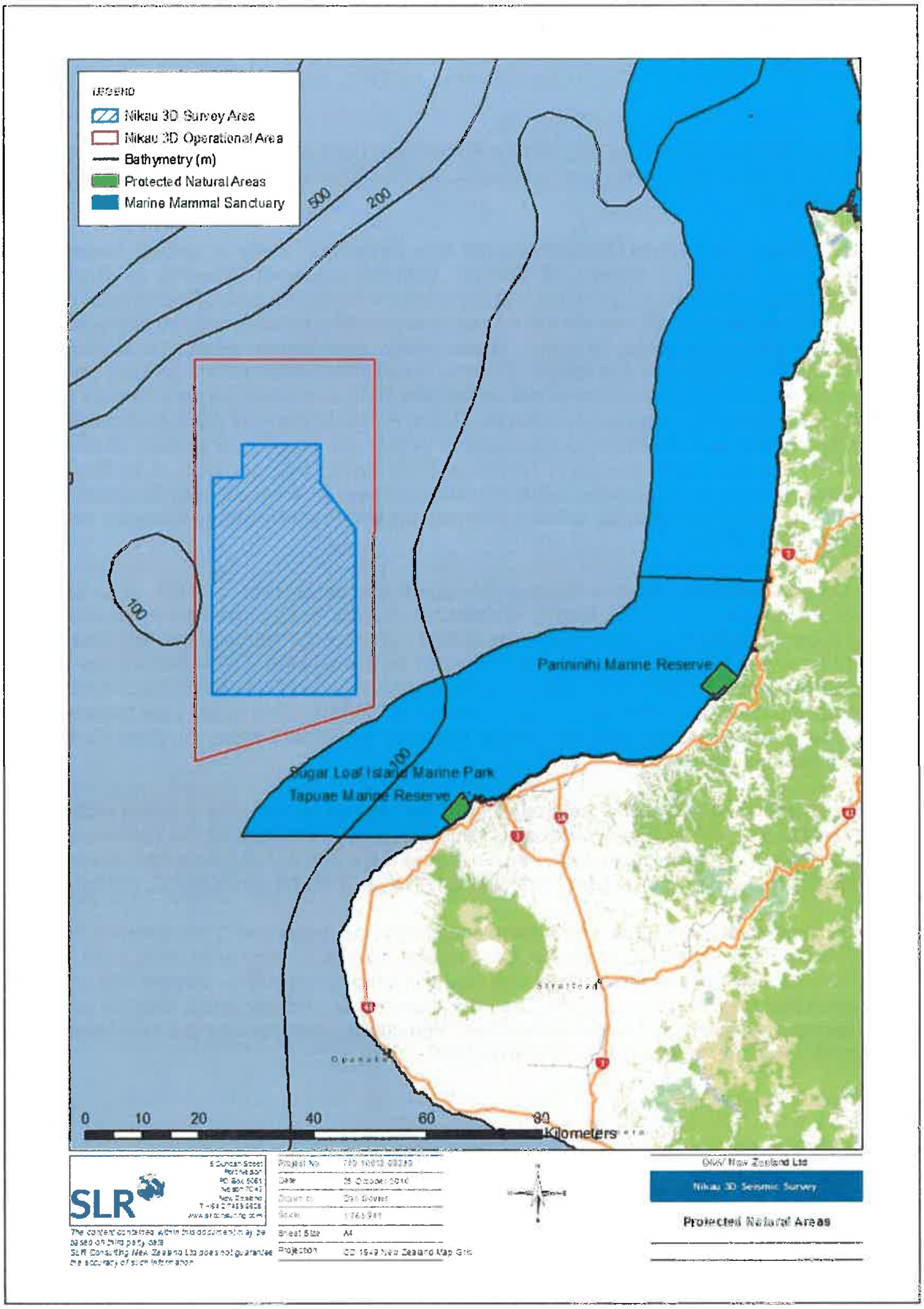
The Ngā Motu/Sugar Loaf Islands Marine Protected Area comprises 749 ha of seabed, foreshore and water around New Plymouth's Sugar Loaf Islands. With the exception of trolling for kingfish and kahawai, all commercial fishing is prohibited within the Marine Protected Area. Recreational fishing is still allowed. The Sugar Loaf Islands are the eroded remnants of a volcano and are characterised by low sea stacks and seven small islands. These stacks and islands provide a semi-sheltered environment on what is otherwise an exposed coastline. Subtidal habitats such as canyons, caves, rock faces with crevices and overhands, large pinnacles, boulder fields and extensive sand flats are all found in the Marine Protected Area. The islands within the Marine Protected Area are the only offshore islands. They are predator free and are afforded the status of Wildlife Sanctuary. 19 species of seabird are associated with Ngā Motu, with upwards of 10,000 seabirds nesting here per year. A breeding colony of New Zealand fur seals is also located within the Marine Protected Area. At least 89 species of fish, 33 species of encrusting sponges, 28 species of bryozoans and 9 species of nudibranchs have been recorded here (DOC, 2016e).

The West Coast North Island Marine Mammal Sanctuary was established in 2008. The sanctuary extends alongshore from Maunganui Bluff in Northland to Oakura Beach, Taranaki in the south. The offshore boundary extends from mean high water springs out to the 12 Nm Territorial Sea limit. A total of 1,200,086 ha and 2,164 km of coastline are protected by the sanctuary. Restrictions are in place within the sanctuary on seabed mining, seismic surveys and commercial and recreational fishing. Set-netting is prohibited within 350 km² of the Sanctuary (DOC, 2016f). The Sugar Loaf Islands Marine Protected Area and Tapuae and Parininihi Marine Reserves are located within the West Coast North Island Marine Mammal Sanctuary.

The Parininihi Marine Reserve covers an area of 1,800 ha. As well as including a typical slice of north Taranaki coastline, the Marine Reserve covers a significant underwater feature; the Pariokariwa Reef. This reef contains some of the highest diversity of sponges in New Zealand and is ranked internationally. Also found at this reef is a high diversity of hydroids, anemones, and soft corals (DOC, 2016g).

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 and includes a range of habitats, such as reefs, mud, sand and boulder platforms as well as 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. Humpback, southern right and killer whales have been observed within the Tapuae Marine Reserve (DOC, 2016).

**Figure 17 Protected Natural Areas near the Operational Area**



### 4.3.4 EEZ and Continental Shelf Regulations Sensitive Environments

Schedule 6 of the EEZ and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (EEZ Regs.) describes 13 sensitive environments that have been identified by the Ministry for the Environment (in consultation with NIWA). 'Sensitivity' is defined as the tolerance of a species or habitat to damage from an external factor and the time taken or its subsequent recovery from damage sustained as a result of an external factor (MacDiarmid *et al.*, 2013). Rarity of a habitat is 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 lover tolerance rating).

**Table 13** lists the species, habitats and indicators considered under Schedule 6 of the EEZ Regs. as sensitive.

**Table 13 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 –<br>• A colony of a structure-forming species (i.e. *Madrepora oculata, Solensomilia variabilis, Goniocorella Dumosa, Enallopsammia rostrate*, and *Oculina virgosa*) covers 15% or more of the seabed in a visual imaging survey of 100 m² or more; or<br>• A specimen of a thicket-forming species is found in two successive point samples; or<br>• 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 –<br>• Colonies of large frame-building bryozoan species cover at least 50% of an area between 10 m² and 100 m²; or<br>• Colonies of large frame-building bryozoan species cover at least 40% of an area that exceeds 10 km²; or<br>• A specimen of a large frame-building bryozoan species is found in a sample collected using towed gear; or<br>• One or more large frame-building bryozoan species is found in successive point samples. |
| Calcareous tube worm thickets | A tube worm thicket exists if –<br>• One or more tube worm mounds per 250 m² are visible in a seabed imaging survey; or<br>• Two or more specimens of a mound-forming species of tube worm are found in a point sample; or<br>• 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 –<br>• Cover 25% or more of the seabed in a visual imaging survey of 500 m² or more; or<br>• Make up 25% or more of the volume of a sample collected using towed gear; or<br>• 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<br>• 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 –<br>• Exists if living coralline thalli are found to cover more than 10% of an area in a visual imaging survey;<br>• Is to be taken to exist if a single specimen of a rhodolith species if found in any sample. |
| Sponges gardens | A sponge garden exists if metazoans of classes Demospongiae, Hexactinellida, Calcerea, or Homoscleromorpha –<br>• Comprise 25% or more by volume or successive point samples; or<br>• Comprise 20% or more by volume of any sample collected using towed gear; or<br>• 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 –<br>• Cover 30% or more of the seabed in a visual imaging survey; or<br>• Comprise 30% or more by weight or volume of the catch in a sample collected using towed gear; or<br>• 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 –<br>• Are found per m² sampled using towed gear; or<br>• 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. |

Complex biogenic structures in homogenic habitats may be created by the presence of bivalve beds, resulting in an increase in species richness. New Zealand bivalve beds are mainly found on the Continental Shelf in water depths less than 250 m. Common suspension feeding species include horse mussels, scallops, and dredge oysters. Suspension feeders have been reported to be particularly well represented off the west coast of the North Island to mid-shelf depths where surface sediments consist mainly of modern terrigenous clean sands and coarser-grained relict terrigenous or biogenic sediment (as referenced in MacDiarmid *et al.*, 2013). Johnston (2016) reported bivalves to be present in the North and South Taranaki Bight, therefore it is likely that this sensitive habitat type will be present in the Operational Area.

Brachiopod shells (including live and dead individuals) contribute to habitat complexity. They occur throughout New Zealand at all depths, predominately on hard substrates in areas with significant water movement free of fine sediments. Brachiopods mainly occur in depths less than 500 m, but may be found from depths over 1,000 m (as referenced in MacDiarmid *et al.*, 2013). Although the North Taranaki Bight is not known to have diverse or abundant brachiopod assemblages (MacDiarmid *et al.*, 2013), Johnston (2016) has reported brachiopods to be present within, or in the vicinity of, the Operational Area.

Where habitat forming bryozoans are found, the surrounding habitat complexity is often enhanced. Habitat forming bryozoans are most commonly found in temperate Continental Shelf environments on stable substrate where water movement is fast and consistent. They are particularly abundant and diverse in New Zealand (MacDiarmid *et al.*, 2013). Johnston (2016) has reported locations of bryozoan thickets in close proximity to the Operational Area.

Calcareous tube worm thickets or mounds can form dense three-dimensional mosaics across the seabed. Mounds of the species *Galeolaria hystrix*, a southern Australia and New Zealand endemic, are the best described example of mound-forming species in New Zealand. This species is present from the Taranaki Coast down to Stewart Island. Johnston (2016) has reported calcareous tube worm thickets along the North Taranaki Bight coast; however, it is unlikely they will be present in the Operational Area as the Taranaki distribution appears to be restricted to shallow coastal waters surrounding Cape Egmont.

Little is known on the role of chaetopteridae tube worms in New Zealand. Although not reported by MacDiarmid *et al.* (2013) to be present in the North Taranaki Bight, Johnston (2016) has reported chaetopteridae worms to be present south of the Operational Area off Cape Egmont.

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, therefore will not be present in the Operational Area.

Macro-algae beds occur on hard rocky substrates in the photic zone down to depths of 200 m. They include species of small foliose brown, red, and green algae, as well as large brown algae/kelp. Macro-algae beds are important components of reef ecosystems (MacDiarmid *et al.*, 2013). MacDiarmid *et al.* (2013) reports macro-algae beds to be present throughout New Zealand's EEZ but does not give any specific sites for Taranaki. Johnston (2016) has not reported any brown, green, or red macro-algae beds to be present in the vicinity of the Operational Area, and it is likely that the Operational Area is too far offshore for any macro-algae beds to be present.

Methane or cold seeps occur where 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. This zone typically occurs 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 have not been recorded in the Taranaki Basin. 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). Little is known on the location of rhodolith beds in New Zealand; however, known locations are typically coastal in nature (MacDiarmid *et al.*, 2013). It is suggested that rhodoliths prefer areas characterised by strong currents within the photic zone, particularly around the margins of reefs or elevated banks (MacDiarmid *et al.*, 2013). Johnston (2016) has reported rhodolith beds along the coast north of Cape Egmont, well inshore of the Operational Area.

Sea pens occur on fine gravels, soft sand, mud, or the abyssal ooze. They occur in areas where turbulence is unlikely to dislodge their anchoring peduncle but where a current exists to ensure a flow of food (MacDiarmid *et al.*, 2013). Johnston (2016) has not recorded sea pens in the Operational Area, however the possibility of the presence of sea pens in the Operational Area cannot be ruled out due to their prevalence in the South Taranaki Bight.

Sponges are dominant in many environments such as shallow coastal rocky reefs, seamounts, hydrothermal vents, and oceanic ridges. In New Zealand demosponges dominate the shelf and coast in water depths down to 250 m, while deeper waters are dominated by the glass sponges. Examples of known sponge gardens in New Zealand include the North Taranaki Bight (MacDiarmid *et al.*, 2013). The Sugar Loaf Islands Marine Protection Area is well known for its high diversity and abundance of sponges (see **Section 4.3.3**) and this area has also been identified by Johnston (2016). Sponge gardens could be present within the Operational Area, although they are more likely to be found inshore of the Operational Area.

Coldwater corals include the Scleractinia (stony corals), Octocorallia (soft corals), Antipatharia (black corals), and Stylasteridae (hydrocorals). Stony corals provide the most complex habitats and can form reefs or thickets (MacDiarmid *et al.*, 2013). See **Figure 9** in **Section 4.2.2** for distribution maps of corals in the Operational Area; although there are no significant densities of coral in the Operational Area.

Xenophyophore beds are often mistakenly identified as broken and decayed 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 to the west of the Operational Area in water depths in excess of 1,200 m and as such are not expected to be present within the Operational Area.

### 4.3.5 Cultural Environment

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

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

This section provides a brief overview of iwi (tribes) along the stretch of coastline relevant to the Operational Area and describes their rohe (area of interest) and the marine attributes of particular cultural interest. The Operational Area adjoins the rohe of five iwi (tribes) as listed in **Table 14** and depicted in **Figure 18**.

Māori people have a deep spiritual connection with whales and dolphins which are the focus of a number of myths and legends. Whales are thought to provide safety at sea and reportedly guided the waka (canoes) on their great journey to New Zealand from the ancestral homelands in the Pacific.

**Figure 18 Iwi boundaries of New Zealand**

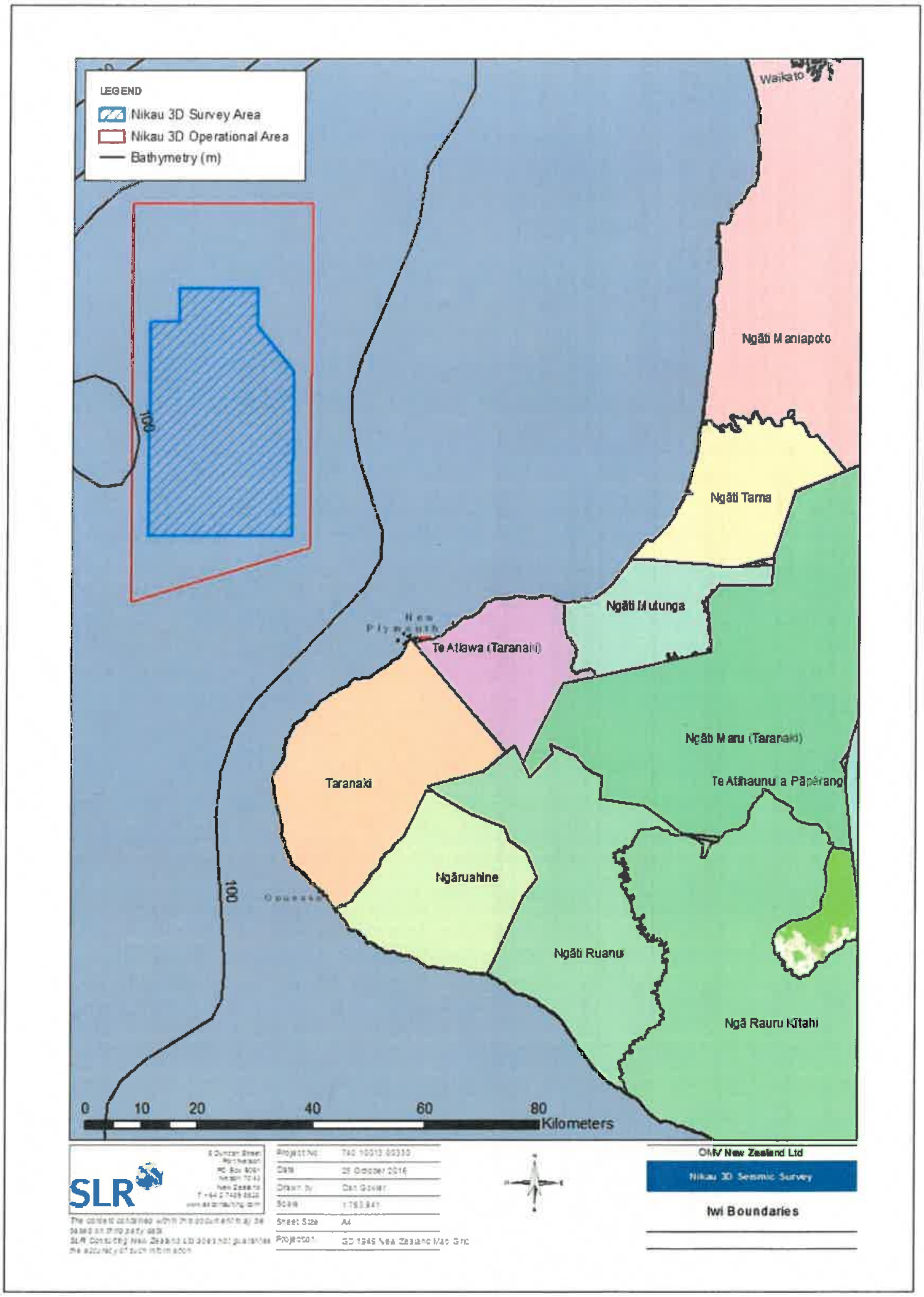


**Table 14 Iwi interests in the Operational Area**

| Iwi (tribal group) | Rohe (area of interest) | Region/s | Taonga (treasured) species* | Further comments |
|---|---|---|---|---|
| Ngāti Maniapoto | From Kawhia Harbour in the north to Tongaporutu in the south | Waikato<br>Taranaki | Tuna (eels), whitebait, smelt, piiharau (lamprey), kanae (mullets), pātiki, kahawai, trevally, tamure (snapper), whoke (octopus), koura (freshwater crayfish), kaaeo, kaakahi (freshwater mussels), tio (oysters), 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). |
| Ngāti Tama | From Mokau in the north to Waiiti in the south | Taranaki | Traditional kaimoana, e.g. mako (shark), tamure (snapper), and araara (trevally) (TRC, 2010). | 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 in decision making alongside the Department of Conservation (DOC) and the Paraninihi Marine Reserve Conservation Board. |
| Ngāti Mutunga | From Waiiti in the north to Waitara in the south | Taranaki | Traditional kaimoana, e.g. mako (shark), tamure (snapper), and araara (trevally) (TRC, 2010). | 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). |
| Te Atiawa (Taranaki) | From Onaero River in the north to Herekawe Stream (near Spotswood) in the south | Taranaki | Traditional kaimoana | Within this rohe lies the Ngā Motu/Sugar Loaf Islands Marine Protected Area. |
| Taranaki Iwi | From Herekawe Stream in the north to Oeo in the south | Taranaki | Traditional kaimoana e.g. paua, kina, kōura (crayfish), kūkū (mussels), pūpū (molluscs), ngākihi (limpets), pāpaka (crab), toretore (sea anemones), tāmure (snapper), kahawai, pātiki (flounder/flatfish), mako (sharks). | The Coastal Marine Area is known to Taranaki iwi as Ngā Tai a Kupe (the shores and tides of Kupe) and contains a number of kaimoana reefs and wāhi tapu sites. Taranaki Iwi places substantial historical and spiritual importance in the Ngā Motu (Sugar Loaf) Islands. The Tapuae Marine Reserve is encompassed by the Taranaki Iwi rohe. |

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

### 4.3.6 Customary Fishing and Iwi Fisheries Interests

The collection of kaimoana is an essential part of Māori lifestyle and relationship with the sea. Kaimoana is seen not only as sustenance for tangata whenua and an important food source for whānau (family), but is also vital for provision of hospitality to manuhiri (guests) (Wakefield & Walker, 2005).

The Maori Fisheries Act (2004) allocated fisheries assets (including fishing quota) to recognised iwi throughout New Zealand. In addition, each iwi was assigned income shares in Aotearoa Fisheries Limited which is managed and overseen by Te Ohu Kai Moana (the Maori Fisheries Commission).

Iwi also have customary fishing rights (for special occasions and day-to-day use) under the Fisheries (Kaimoana Customary Fishing) Regulations 1998. These regulations stem from the Treaty of Waitangi (Fisheries Claims) Settlement Act (1992) and are separate, and in addition to, the commercial fisheries assets described above. Under these regulations Māori can be permitted to harvest kaimoana for customary purposes in a way that exceeds levels permitted in standard practice (e.g. harvesting more than typically permitted or harvesting in closed areas) (Maxwell, 2012). The methods of establishing customary fishing rights are described below and the locations subject to customary rights are illustrated in **Figure 19**.

#### 4.3.6.1 Rohe Moana

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

- Nga Hapu o Aotea Moana (located in Aotea Harbour, 40 km$^2$)
- Ngāti Hikairo, Ngāti Mahuta and Ngāti Maniapoto Rohe Moana (6,875 km$^2$)
- Ngāti Mahuta ki Taharoa Rohe Moana (7,379 km$^2$)
- Ngāti kinohaku, Ngāti Te Kanawa and Ngāti Peehi Rohe Moana (represented by Marakopa Marae) (8,858 + 5,024 km$^2$)
- Ngāti kinohaku Rohe Moana (represented by Oparure Marae) (5,878 km$^2$)
- Ngāti Haumia Rohe Moana (represented by Orimupiko Marae) (59 km$^2$); and
- Titahi-Ngaruahine Rohe Moana (represented by Ouri Māori Committee) (41 km$^2$)

#### 4.3.6.2 Mātaitai Reserves

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

- Aotea Harbour Mātaitai Reserve (commenced on 08/05/2008 over approx. 40 km$^2$); and
- Marokopa Mātaitai Reserve (commenced on 13/01/2011 over approx. 68 km$^2$).

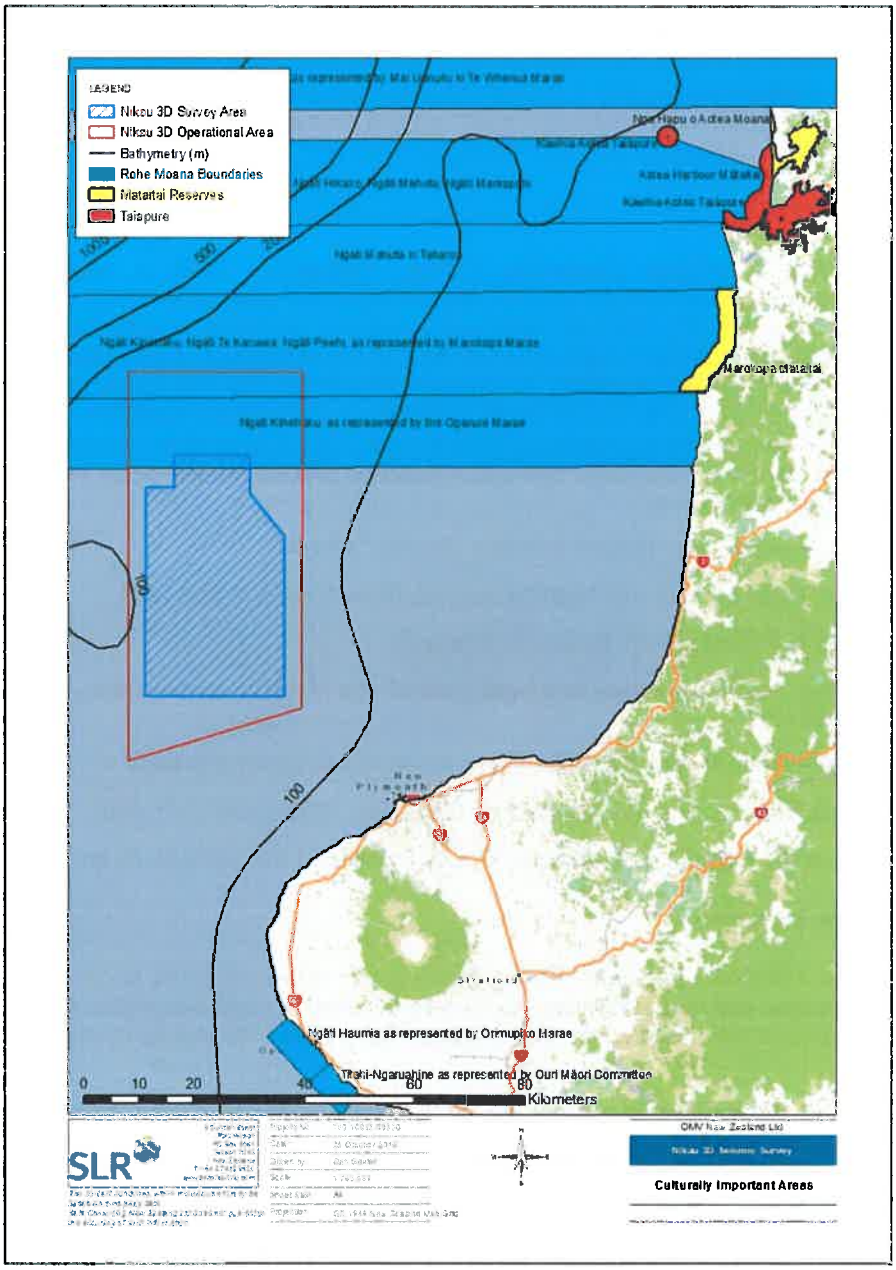
### 4.3.6.3 Taiapure

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

- Kawhia Aotea Taiapure (located in Kahia Harbour, commenced on 08/05/2000)

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

**Figure 19: Rohe Moana, Mataitai and Taiapure in the Vicinity of the Operational Area**



## 4.4 Anthropogenic Environment

This section focuses on the users of the environment within and in the vicinity of the Operational Area. Particular emphasis has been put on recreational and commercial fishing, shipping, and the petroleum industry.

### 4.4.1 Recreational Fishing

The majority of the Operational Area is not often fished by recreational fishers due to its distance offshore (beyond the 12 Nm Territorial Sea); however, despite weather limitations the inshore coastline at the southeast end of the Operational Area is frequently utilised by recreational fishers.

The west coast of the North Island (central west region) contains regionally significant recreational fisheries, including reef, beach and boat fisheries, and a nationally significant blue-water recreational fishery for warm-water pelagic species (MFish, 2016).

The coast adjacent to the Operational Area contains a mix of sandy beaches and sea cliffs. Although the shore fishing opportunities are limited along this coastline, the offshore fisheries for snapper, kingfish, hapuka/bass, trevally, kahawai, tarakihi, and gurnard are significant (MPI, 2016). Set-netting is not allowed along this coastline on account of the West Coast North Island Marine Mammal Sanctuary (see **Section 4.3.3**).

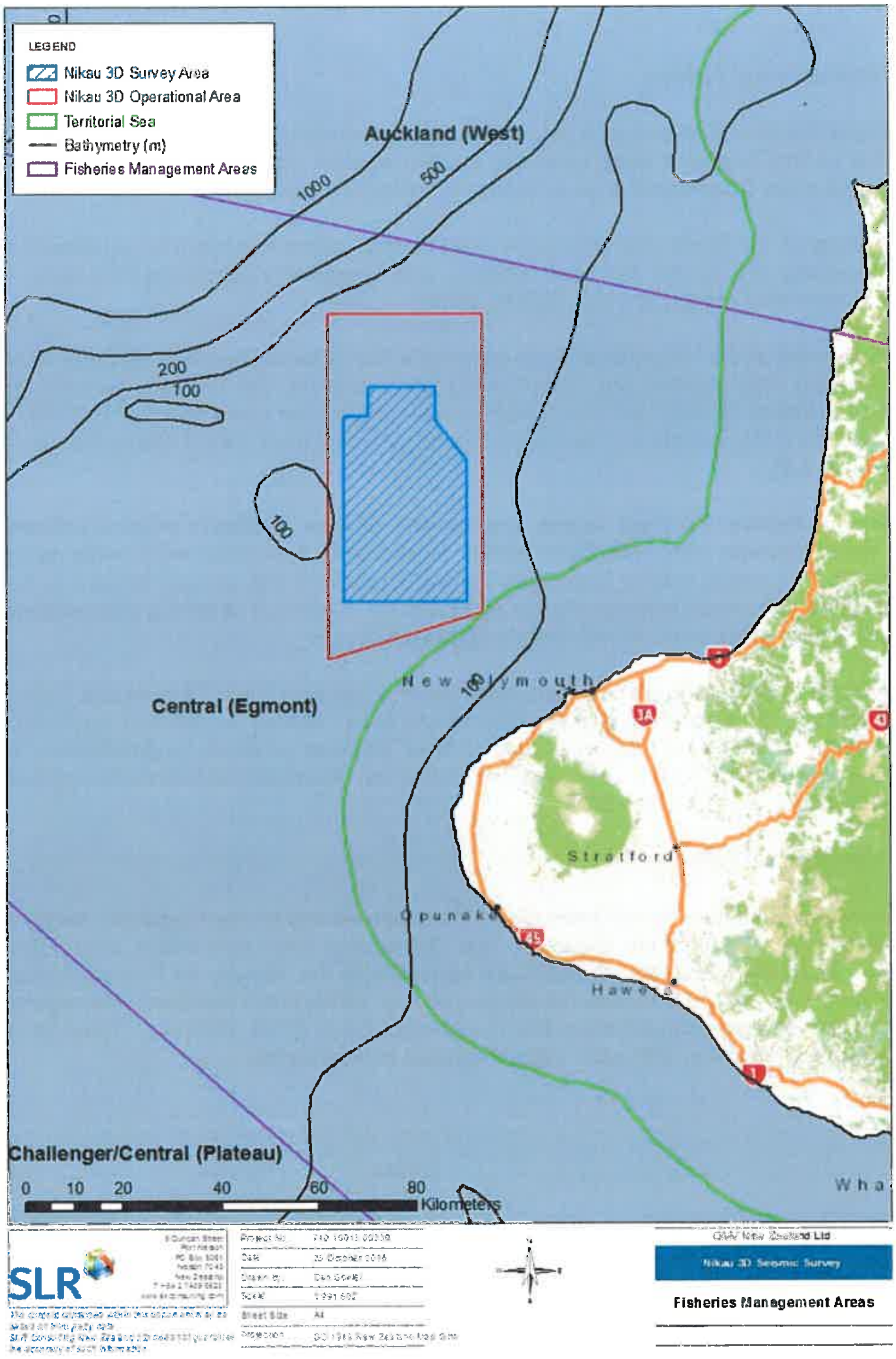
During summer months Taranaki waters support one of New Zealand's most significant big-game fisheries; warm currents bring with them billfish, tuna, marlin and other warm-water pelagic species (MFish, 2016). The marlin season in offshore Taranaki runs from late January through to April, with the majority of game fish caught in water depths up to 200 m. A number of fishing competitions organised by Taranaki fishing clubs coincide with these big game fisheries.

The main pelagic sport fishing area for Taranaki fishers is between Cape Egmont and Tirua Point along the 100 m isobath. This area includes the Operational Area. Mokau Trench and Southern Trench are also targeted by sport fishers; however, due to their distance offshore (approximately 110 km) the trenches are only targeted in very good weather conditions. Recreational bottom fishing is also popular and occurs mostly in depths of 60–80m.

### 4.4.2 Commercial Fishing

Ten Fisheries Management Areas have been implemented within New Zealand waters in order to facilitate the Quota Management System. The Operational Area falls within area FMA8 (Central) (**Figure 20**). Fisheries Management Areas are regulated by the Ministry for Primary Industries. Over 1,000 fish species occur in New Zealand waters (Te Ara, 2016a) with the Quota Management System providing for the commercial utilisation and sustainable catch of 96 species. These 96 species are divided into separate stocks, with each stock managed independently.

**Figure 20 Fisheries Management Areas in Relation to the Operational Area**



In general, FMA8 supports a mixed trawl fishery for snapper, gurnard, tarakihi, trevally, and white warehou. Long-lining for snapper, potting for rock lobster, and set netting for rig and school shark (outside of the Marine Mammal Sanctuary) also occur (MPI, 2016a).

The top five species of finfish caught within FMA8[1] according to Total Allowable Commercial Catch (TACC) are presented in **Table 15** below (MPI, 2016a). Total Allowable Commercial Catch represents the total quantity of each fish stock that the commercial fishing industry can catch in a given year (MPI, 2016a). The catch presented in **Table 15** represents the TACC for the 12 month period to 30 September 2017.

**Table 15 Total Allowable Commercial Catch Allocations for Finfish in FMA8**

| Species | Stock | TACC (tonnes) |
|---|---|---|
| Trevally | TRE7 | 2,153 |
| Snapper | SNA8 | 1,300 |
| Leatherjacket | LEA2 (2,7 and 8 combined) | 1,136 |
| Gurnard | GUR8 | 543 |
| School shark | SCH8 | 529 |

Although **Table 15** provides an indication of commercially targeted fish species, the Operational Area is much smaller than FMA8; therefore, regional variations are not well represented by TACC data. Fisheries data in the immediate vicinity of Cape Egmont (including the Operational Area) is summarised by Gibbs (2015). Gibbs (2015) described the primary commercial fishery in the Cape Egmont area as a mid-water trawl fishery for jack mackerel. The jack mackerel fishery operates year round, with catch peaking in October – January and April – July. In trawls targeting jack mackerel, about 20% of the catch typically consists of other species (barracouta, blue mackerel and frostfish).

Commercial trawling effort occurs year round in FMA8. Although there is no seasonality when viewed as a whole, catch of certain species is seasonal, including snapper and John dory catch peaks in October – March, and trevally catch peaking in January – February (Gibbs, 2015).

Gibbs (2015) also outlines other fisheries in the vicinity of the Operational Area as:

- Inshore mixed trawl fisheries (e.g. snapper, gurnard, trevally, barracouta, leatherjacket, tarakihi and john dory);
- Inshore set net fisheries where permitted (school shark and rig);
- Coastal fisheries (rock lobster, paua, scallops and other shell fish); and
- Various smaller fisheries (potting, lining or trolling)

Consultation has been undertaken with fishing groups that use the North Taranaki Bight (see **Section 1.3**) to advise them of the proposed seismic operations and the span of gear that will be used. A summary of engagements is provided in **APPENDIX B**. These groups will be provided with contact details of the vessel closer to the commencement date and will have access to web-based real-time updates of the seismic vessels position.

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[1] Only species with a stock that includes the Operational Area have been included in Table 1. For example Rig stock SPO1 covers part of FMA8 but does not include the Operational Area.

### 4.4.3 Commercial 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, and has a maximum draft of 12.5 m. It is a modern port, offering nine fully serviced berths that cater to a wide variety of cargo requirements. Cargo moving through Port Taranaki is typically related to the farming, engineering and petrochemical industries.

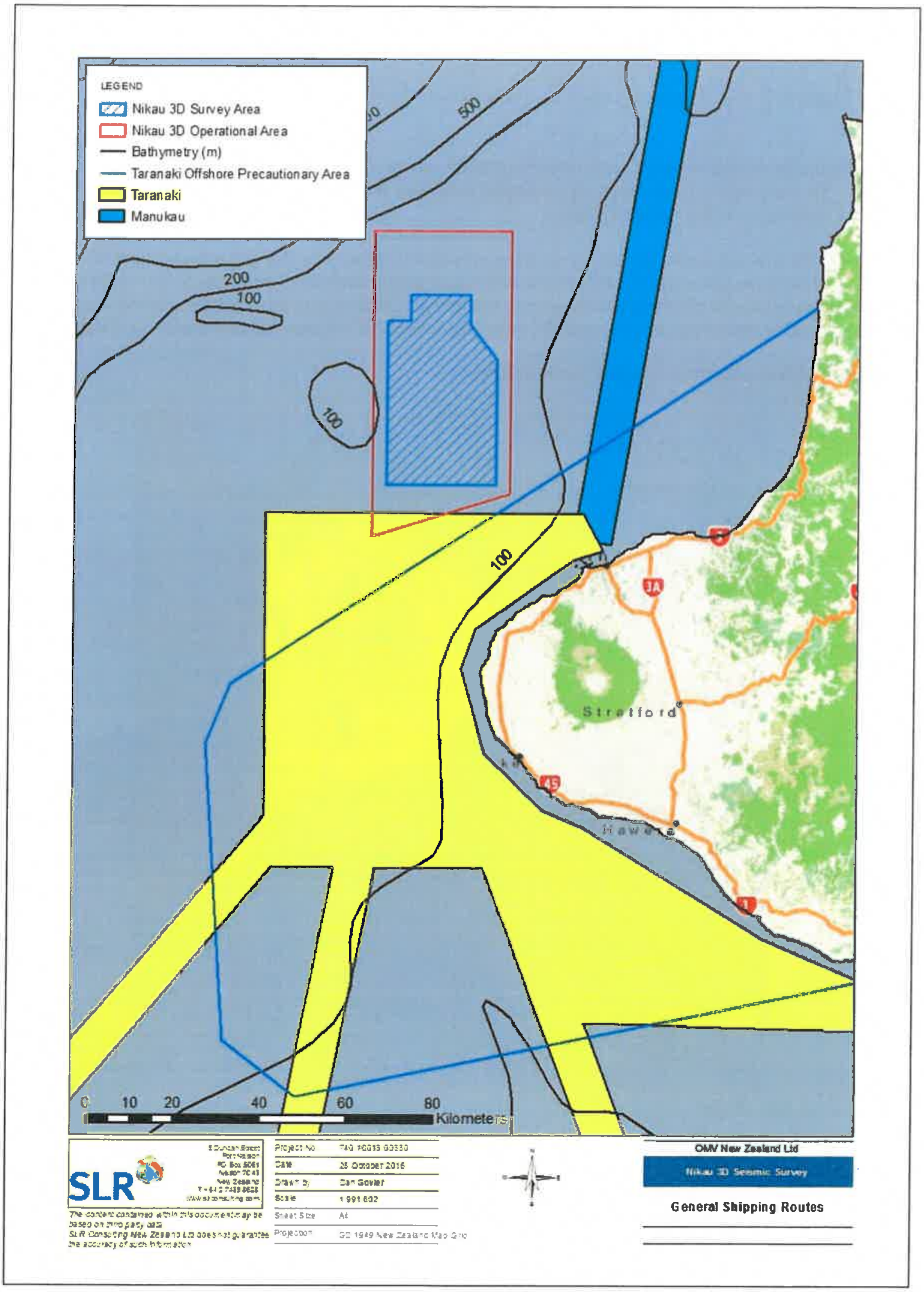
There are no dedicated shipping lanes between Port Taranaki and any other New Zealand port; commercial shipping vessels will take the shortest route with consideration of the weather conditions and forecast at the time. The general shipping routes between New Zealand ports in the vicinity of the Operational Area are shown in **Figure 21.**

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 by the International Maritime Organisation in 2007. On account of the high abundance 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.

The 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. Hazards include the Pohokura, Māui, Maari, Tui and Kupe production fields.

**Figure 21 General Shipping Routes Within and Surrounding the Operational Area**



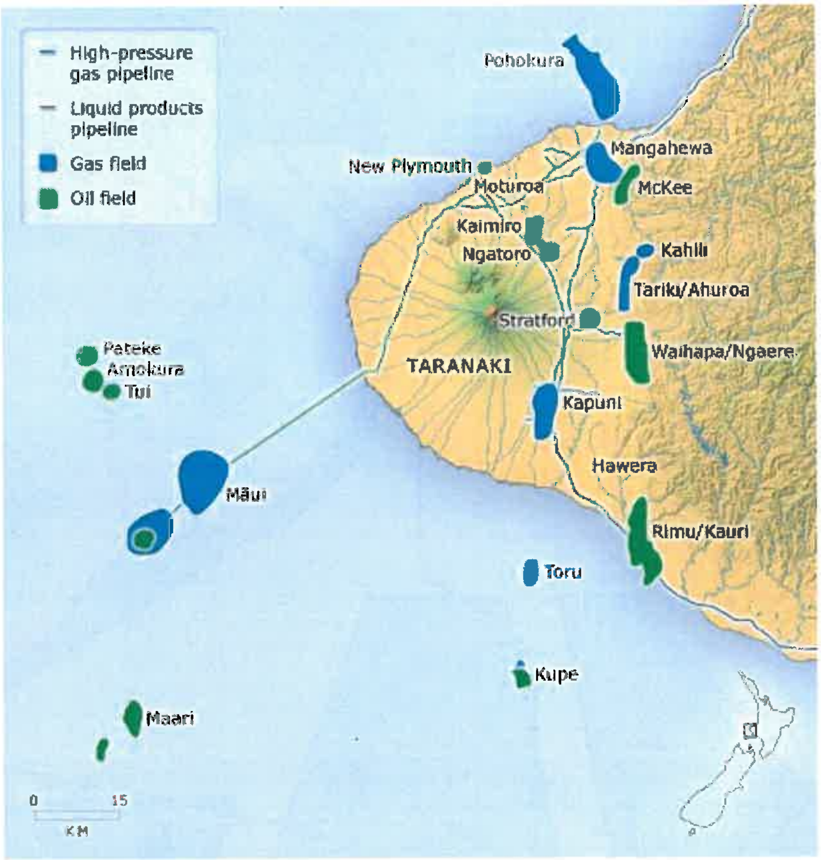
### 4.4.4 Petroleum Exploration

Hydrocarbon exploration and production activities in Taranaki have been ongoing for the last 100 years and offshore for more than 50 years. Since exploration began, more than 350 onshore and offshore wells have been drilled. All of New Zealand's offshore producing oil and gas fields are currently located in the Taranaki Basin. Producing offshore fields include: Maari, Māui, Kupe, Pohokura, and Tui (**Figure 22**).

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.

SLR or OMV are not aware of any other planned seismic survey for the proposed operational period; hence at this stage, a temporal overlap of seismic operations is unlikely although concurrent operations should be re assessed closer to the survey commencing. Other oil and gas activities (aside from seismic surveys) may however occur concurrently, including well head inspections and anchoring changes.

**Figure 22 Oil and Gas Fields in the Taranaki Basin**



Source: Te Ara, 2016d.

# 5 POTENTIAL ENVIRONMENTAL EFFECTS AND MITIGATION MEASURES

This section presents an overview of the potential environmental effects that may arise from the operation of the Nikau 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.

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 16**). The joint Australian & New Zealand International Standard Risk Management – Principles and Guidelines, (ASNZS ISO 31000:2009) has been used to develop the ERA. These guidelines define risk as 'the uncertainty upon objectives', while the effect is a deviation from the expected – either positive or negative. This assessment considers the consequence (**Table 17**) and likelihood (**Table 18**) of each potential environmental effect, including its geographical scale and duration. A description of the risk categories is provided in **Table 19.**

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

The main steps used in the Environmental Risk Assessment are:

- Identification of the sources of potential effects;
- Description of potential effects;
- Identification of potential environmental receptors and their sensitivity to potential effects;
- Development of measures to avoid, remedy or mitigate each potential effect; and
- Determine the risk associated with any residual effects (in accordance with **Table 16, Table 17** and **Table 18**).

**Table 16: Environmental Risk Assessment Matrix**

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

**Table 17: Consequence Definitions for Residual Effects**

| Consequence level | Underwater noise | Populations | Magnitude & Recovery Period | Proportion of habitat affected | Existing Interests (fisheries – commercial or recreational, cultural, social, shipping etc.) |
|---|---|---|---|---|---|
| 4 - Catastrophic | Significant numbers of marine mammals exposed to SELs greater than 218[2] 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. |

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[2] Permanent threshold shifts are thought to occur between 218 – 230 dB re 1 µPa2-s (Southall et al., 2007).

**Table 18: 'Likelihood' Definitions 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 19: Risk Category Definitions for Residual Effects**

| | | |
|---|---|---|
| 🟥 | Extreme Risk:<br>(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:<br>(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:<br>(3 - 6) | No additional mitigation actions required for short-term operations, but long-term operations should consider additional mitigation measures. Some effects on marine fauna (e.g. behavioural response or masking) or existing interests (displacement) are expected. |
| 🟩 | Low Risk:<br>(0 - 2) | No regulatory violation or requirement for additional mitigation actions anticipated. No significant effects on marine fauna or existing interests are expected. |

**Table 20** summarises the sources and potential effects that could occur from planned activities during the Nikau 3D Seismic Survey. These potential effects, their proposed mitigations and the associated ERA results are described in detail through the remainder of this section. The Potential effects from unplanned events are also discussed at the conclusion of this section.

**Table 20 Potential sources of effect associated with planned activities**

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

## 5.1 Planned Activities – Potential Effects and Mitigations

### 5.1.1 Presence of seismic vessel and towed equipment

The physical presence of the survey vessels and the associated towed equipment could potentially affect marine fauna and existing interests. Each potential effect is discussed below.

#### 5.1.1.1 Potential effects on marine mammals

The four main ways in which vessel presence could affect marine mammals are as follows:

1) Disruption of normal behaviour;

2) Displacement of individuals from habitat;

3) Ship strikes - collision between a marine mammal and vessel; and

4) Entanglement risks associated with towed equipment.

Behavioural disruption and displacement are of great concern when these are initiated on a frequent basis and/or over a prolonged period and/or they affect critical behaviours such as feeding, breeding and resting. Although there is potential for the physical presence of the survey vessels and associated acoustic equipment to cause some changes in marine mammal behaviours and/or displacement from habitat, such disturbance is predicted to be temporary and localised during the Nikau 3D Seismic Survey due to the limited duration of survey operations. In addition, in order to be affected by the presence of the survey vessels and associated equipment, a marine mammal must first be in close proximity while the seismic vessel is acquiring.

In 2003, a study was published by Jensen and Silber which reviewed 292 records of ship strike. From this study, 11 species were identified as at risk from ship strike with fin whales (75 records) and humpback whales (44 records) at the top of the list. Nine of the species which are thought to occur in the Operational Area feature on this list: Bryde's whales, blue whales, fin whales, humpback whales, killer whales, minke whales, sei whales, southern right whales, and sperm whales.

The same study also highlighted that vessel type and speed are defining factors in the severity of a ship strike incident. Navy vessels and container/cargo ships/freighters are involved in the majority of fatal ship strikes: with records indicating that seismic vessels have only been responsible for one known fatality globally since records began in the late 1800s (Jensen & Silber, 2003). Records of sub-lethal effects are less reliable on account of the difficulty in assessing injury in free swimming cetaceans following a collision. However, the primary cause of lethal ship strikes is the speed at which the vessel is travelling; with likelihood of mortality increasing with vessel speed. The mean fatal speed reported by Jensen and Silber (2003) is 18.6 kts. Further, Vanderlaan and Taggart (2007) found that the chance of lethal injury to cetacean when struck was 80% at 15 knots decreasing dramatically to 20% at 8.6 knots. The typical speed of a seismic vessel during acquisition is ~4.5 knots; less than four times slower than the mean fatal speed reported by Jensen & Silber (2003).

The possibility of marine mammals becoming entangled in towed seismic equipment cannot be discounted; however, this is highly unlikely to occur. Not only do marine mammals have incomparable abilities of detection and avoidance of obstacles, but the equipment has no loose surface lines or any attractants (as opposed to fishing gear). To SLR's knowledge, there has never been a reported case of a marine mammal becoming entangled in seismic equipment.

In accordance with the Code of Conduct, MMOs will be on-watch during daylight hours for all periods of acquisition during the Nikau 3D Seismic Survey. In addition to this, at least one MMO will be stationed on the bridge during good weather while the seismic vessel is in transit to and from the Operational Area in order to maximise the marine mammal data collected during the survey. The Marine Mammal Mitigation Plan (MMMP) outlines the protocol that MMOs will following during the Nikau 3D Seismic Survey; this is included as **Appendix D**.

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

Given the information detailed above, it is considered that the risk to marine mammals arising from the physical presence of the survey vessels and towed equipment during the Nikau 3D Seismic Survey is ***medium*** (minor x likely).

#### 5.1.1.2 Potential effects on seabirds

A high number of seabirds are likely to be present within the Operational Area (see **Section 4.2.7**), which increases the likelihood of an encounter between seabirds and the seismic vessel during the Nikau 3D Seismic Survey.

Interactions between seabirds and vessels at sea are frequent and range from neutral interactions such as providing perching opportunities to negative interactions such as collisions or entanglements. Fledglings and novice flyers in coastal locations are thought to be at particular risk of disorientation and collisions caused by artificial lighting (Black, 2005; Telfer *et al.*, 1987).

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

Even though no specific mitigations are in place to reduce the likelihood of a collision between seabirds and the survey vessels, the vessels used in the Nikau 3D Seismic Survey confer no greater collision threat than any other vessel in the area would. Furthermore, the slow operational speed of the vessels reduces any potential for detrimental interactions; in fact the presence of the seismic vessel could provide a resting place for seabirds that would otherwise be unavailable. The short-term duration of the survey limits the temporal scale of potential effects (both negative and positive).

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

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

#### 5.1.1.3 Potential effects on fisheries and marine traffic

The Nikau 3D Seismic Survey will potentially create some disturbance to commercial fishing activities by causing temporary displacement of fishing operations while the survey passes through fishing grounds. Additionally, fish stocks may also be temporarily displaced during seismic data acquisition in the area.

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

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

- Seismic operations will occur 24 hours a day, 7 days a week (weather and marine mammal encounters permitting) to minimise the overall duration of the survey;
- The survey vessels will comply with the COLREGS (e.g. radio contact, day shapes, navigation lights, etc);
- Support vessels will be present;
- OMV will issue a Notice to Mariners and a coastal navigation warning will be broadcast on marine radio; and
- A tail buoy with lights and radar reflector will be displayed at the end of each streamer to mark the overall extent of the towed equipment.

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

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

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

Areas of archaeological interest or cultural significance are typically associated with intertidal and subtidal coastal environments, instead of offshore areas like those in the Operational Area.

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

### 5.1.2 Acoustic disturbance to the marine environment

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

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

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

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

The potential effects of acoustic disturbance can include:

- Behavioural changes and related effects such as displacement, disruption of feeding, breeding or nursery activities;
- Perceptual effects such as interference with communications and masking of biologically important sounds; or
- Physiological effects such as changes in hearing thresholds, damage to sensory organs, or traumatic injury.

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

DOC developed the Code of Conduct as a tool to specifically minimise the potential effects of acoustic disturbances from seismic surveys, particularly with regard to behavioural and physiological effects. Complying with the Code of Conduct is the primary way in which potential acoustic effects from the Nikau 3D Seismic Survey will be managed.

Potential acoustic exposure of marine fauna during the Nikau 3D Seismic Survey was assessed by STLM. STLM uses input parameters specific to the source array, and bathymetry data of the Operational Area. This modelling is required by the Code of Conduct for surveys that will occur within an Area of Ecological Importance (see **Section 3.4.3**). The results of the STLM are presented below.

#### 5.1.2.1 Sound Transmission Loss Modelling

SLR undertook STLM to predict received SELs from the Nikau 3D Seismic Survey to assess for compliance with the mitigation zones outlined in the Code of Conduct (short-range modelling) and to predict sound propagation into sensitive areas (long-range modelling). The modelling methodology addressed both the horizontal and vertical directionality of the acoustic array and considered the different water depths and substrate types found throughout the Operational Area. The complete modelling report is provided in **Appendix C**.

In order to select the best model inputs, a number of variables were assessed, including: water depth, proximity to sensitive sites, seasonal sound speed profiles through the water column, and substrate type. The worst case modelling location and conditions were selected to predict the highest SELs possible during the Nikau 3D Seismic Survey, as follows:

- A single modelling location was suitable for both the short-range and long-range modelling (**Figure 23**). This location was deemed suitable for both on account of it:
  - being the shallowest water depth (114 m) in the Operational Area (ideal for short-range modelling), and
  - the closest location to the West Coast North Island Marine Mammal Sanctuary (ideal for long-range modelling);
- A spring sound speed profile was selected as sound travelled fastest during spring conditions; and
- A fine sand seabed was selected as this substrate type is the most reflective substrate present in the Operational Area.

With regards to substrate type, the continental shelf around New Zealand is covered mainly with land-derived sand, gravel and mud sediment (**Figure 24**).

**Figure 23: Short- and long-range modelling location for the Operational Area**

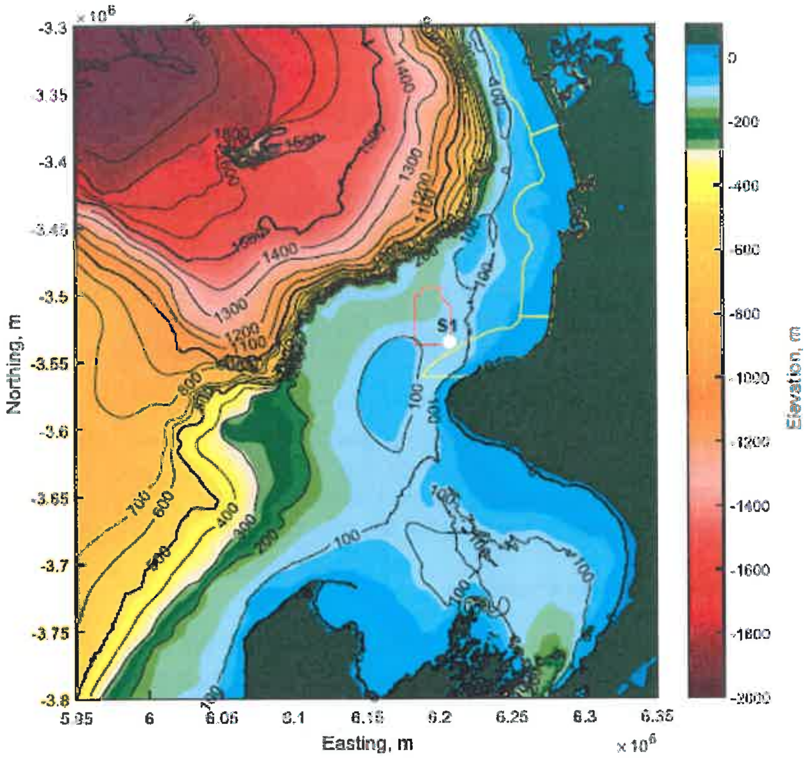
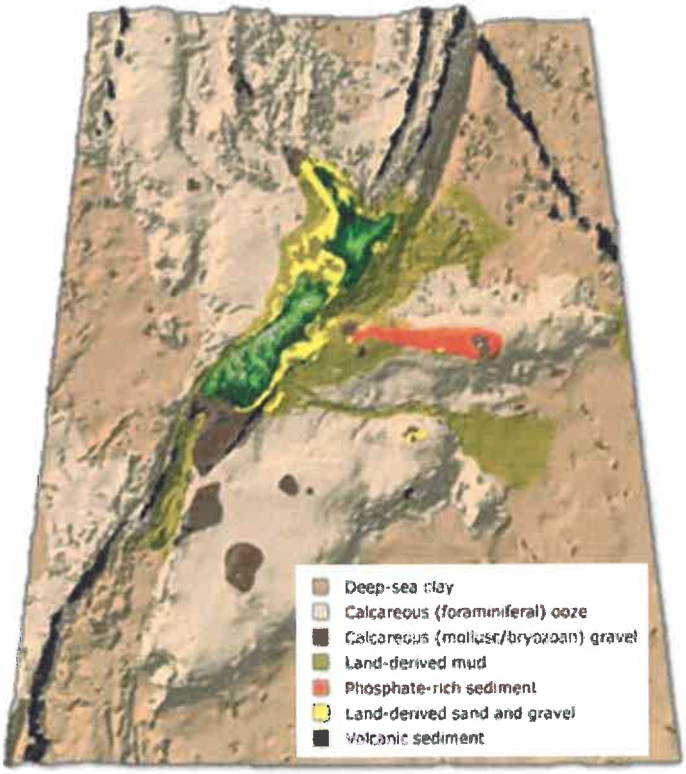


**Figure 24: A Summary of Geo-acoustic Regions of New Zealand**



***Short range modelling results***

Short range modelling allows for predictions to be made about the likelihood of compliance with the standard Code of Conduct mitigation zones. The model results are illustrated in **Figure 25** and predict that the maximum SELs were:

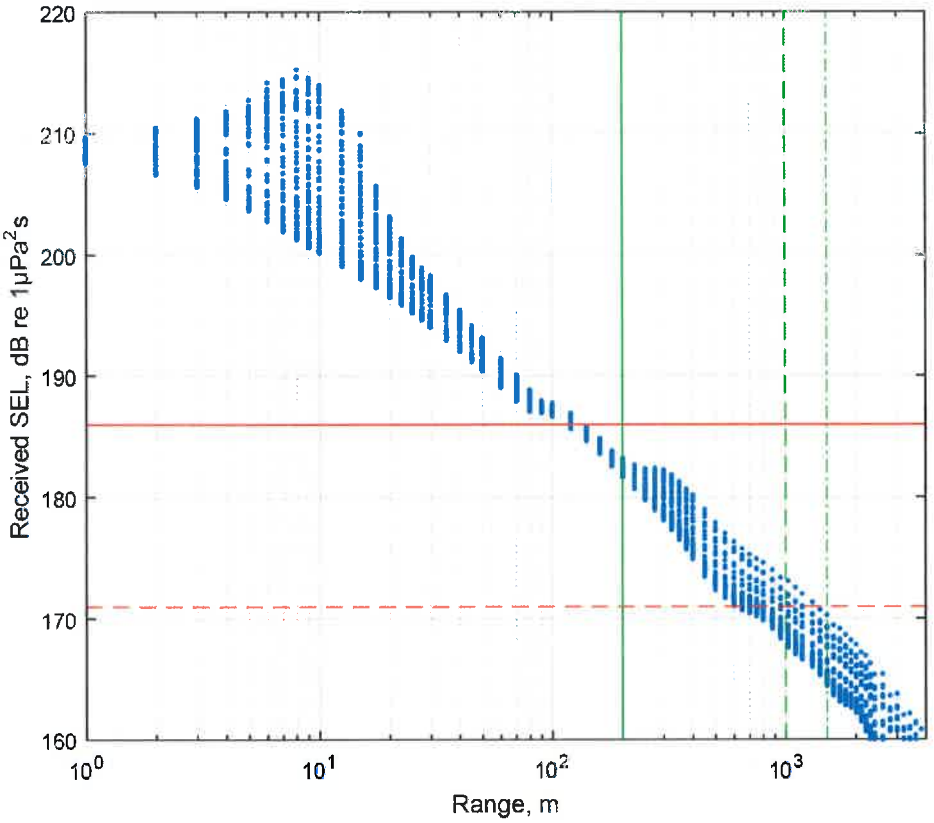
- in compliance with the physiological threshold (< 186 dB re 1 µPa$^2$-s at a distance of 200 m);
- exceeded the behavioural threshold for Species of Concern without calves (> 171 dB re 1 µPa$^2$-s at a distance of 1,000 m)
- in compliance with the behavioural threshold for Species of Concern with calves (< 171 dB re 1 µPa$^2$-s at a distance of 1,500 m)

These results indicate that a larger mitigation zone will be required to sufficiently protect Species of Concern without calves from behavioural disturbance. For this reason OMV proposes to use a 1,500 m mitigation zone for both Species of Concern with or without calves.

Subsequent to the short range modelling, the Operational Area was revised slightly to ensure full fold production can occur over the survey area and sufficient room for the soft starts. As a result, the southeast corner of the revised Operational Area is located 3.6 km to the southeast of the modelled location. The water depth at the southeast corner of the revised Operational Area is 110 m; however, this is still considered to be representative of the modelled location.

The modelling showed that the behavioural threshold for Species of Concern (171 dB re 1 µPa$^2$-s) was met at a distance of 1,340 m from the acoustic source based on a water depth of 114 m. Therefore, the extension of the mitigation zone for Species of Concern without calves to 1,500 m is still considered to be conservative and will ensure that the mitigation zones in place for the Nikau 3D Seismic Survey will be compliant with the Code of Conduct.

**Figure 25: Maximum received SELs from the acoustic source at a water depth of 114 m**



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

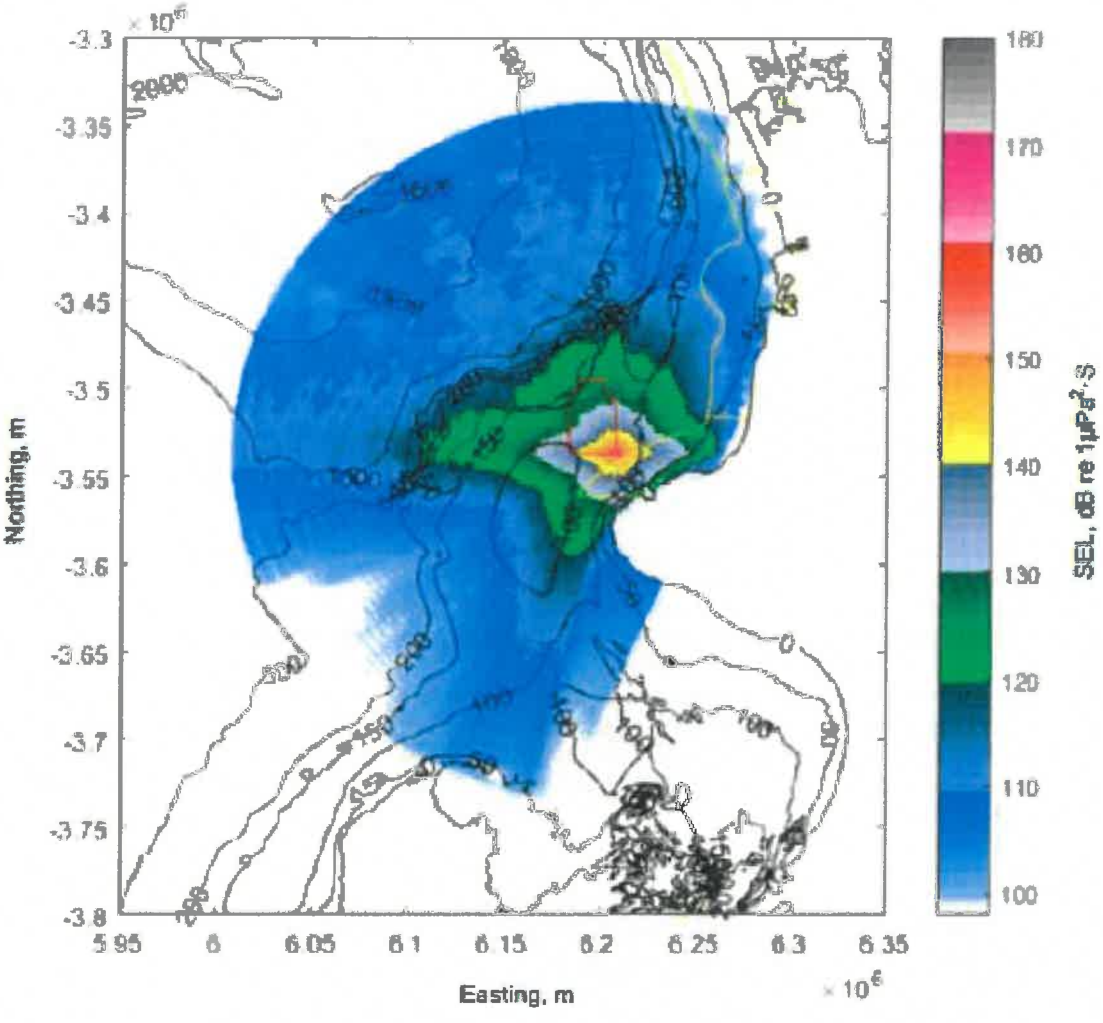
### *Long range modelling results*

Long-range modelling predicted that the received noise levels at far-field locations vary significantly with angle and distance from the source (**Figure 26**). These varying far-field SELs are due to a combination of the directivity of the source array, and propagation effects caused largely by the bathymetry and sound speed profile variations. Sound travelling 'up-slope' (from deep to shallow water) attenuates rapidly as can be seen to the south and southeast directions; whereas sound traveling down-slope propagates extensively in the northern and western directions.

The boundary of the West Coast North Island Marine Mammal Sanctuary is approximately 5.5 km from the source location L1. The maximum SELs at the sanctuary boundary are predicted to be 150 dB re 1 μPa$^2$-s; which is below the thresholds defined by the Code of Conduct. The majority of the marine mammal sanctuary areas within a 50 km distance from the source location between the south and the east direction have predicted received noise levels to be above 120 km. For those areas within the marine mammal sanctuary that are beyond 50 km, the received noise levels are predicted to drop from 120 dB re 1 μPa$^2$-s at the east-northeast direction to values below 100 dB re 1 μPa$^2$-s near the coastline within 200 km distance at the north-northeast direction. These results indicate that marine mammals within the sanctuary are not expected to be subject to either behavioural or physiological disturbance.

The inshore corner of the revised Operational Area is now located 3.6 km closer to the West Coast North Island Marine Mammal Sanctuary than the modelled location. With the revised Operational Area at a distance of 1.9 km from the West Coast North Island Marine Mammal Sanctuary the short range modelling results were used to undertake an SEL assessment, and it was determined that the maximum received SEL at the boundary is 168 dB re 1 µPa²-s. With larger distances from the Operational Area, the SELs will still be consistent with the levels predicted in the long range modelling results above given the water depths are very similar between the modelled Operational Area and the revised Operational Area. Based on this, the SELs at the boundary and inside the West Coast North Island Marine Mammal Sanctuary will still be below the thresholds defined in the Code of Conduct.

**Figure 26 Maximum SELs predicted from the source location over a range of 200 km**



### 5.1.2.2 Potential behavioural effects on marine fauna

Perhaps the most well recognised behavioural response to seismic surveys is an avoidance response whereby animals are temporarily displaced from the area of seismic operations. While short-term displacement is thought to have very limited or no long-term implications for a population, any long-term displacement could lead to an animal relocating to sub-optimal or high-risk habitats. Long-term displacement can therefore result in negative consequences such as an increase in exposure to predators or decreased foraging or mating opportunities. Should any distributional changes occur as a result of the Nikau 3D Seismic Survey, these will be strictly temporary and will only last for the expected 30 day duration of the survey.

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

***Marine mammals***

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

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

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

Below are examples of avoidance responses from different species.

- Humpback whales exposed to 160 – 170 dB re 1 µPa (peak to peak) sounds from seismic surveys consistently changed their course and speed to avoid any close encounters with the seismic array (McCauley et al, 2003).
- Thompson *et al.*(2013) found that displacement of harbour porpoises was observed when the study animals were exposed to peak-to-peak sound pressure levels of 165–175 dB re 1 µPa (a 470 $in^3$ acoustic source over ranges of 5–10 km). For harbour porpoises, displacement was temporary, with the animals detected again at affected sites within a few hours of exposure and a degree of habituation towards the sound source was also observed, with the level of response declining throughout the 10 day survey period (Thompson *et al.*, 2013).
- The effects of a seismic survey on the migratory behaviour of bowhead whales were documented by Richardson *et al.* (1995), with evidence found for a 20–30 km avoidance zone around the seismic vessel. Such displacement is unlikely to have significant energetic consequences for migrating whales when in open seas, but could have greater effects in confined waterways.

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

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

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

- Cerchio *et al.* (2014) documented a significant decrease in the number of 'singers' (associated with breeding behaviour) in a humpback whale population off Northern Angola during seismic surveys;
- Pirotta *et al.* (2014) documented that the buzz rate (associated with feeding behaviour) of harbour porpoises decreased during a seismic survey;
- Di Iorio and Clark (2010) documented an increase in the rate of blue whale calls during a low/medium powered seismic survey which used a sparker as the seismic source;

- Bowles *et al.* (1994) documented a decrease in sperm whale and pilot whale vocalisations during controlled exposure to underwater noise;
- IWC (2007) documented a decrease in sperm whale 'creaks' (associated with feeding behaviour) and that fin whales stopped calling (associated with breeding behaviour) during a seismic survey; and
- Blackwell *et al.* (2015) documented changes in calling rates of bowhead whales in response to seismic surveys. 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 1μPa2-s), then began decreasing (at SELs greater than 127 dB re 1μPa2-s), with whales falling virtually silent once SELs exceeded 160 dB re 1μPa2-s.

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

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

OMV intends to reduce the behavioural effects on marine mammals during the Nikau 3D Seismic Survey by:

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

Based on the information above, some marine mammal behavioural effects are possible when marine mammals are in the vicinity of the Nikau 3D Seismic Survey. These effects will be strictly temporary due to the short operational period and will cease as soon as the survey ceases. It is considered that acoustic disturbance will confer a ***medium*** (possible x moderate) risk of behavioural effects to marine mammals during the Nikau 3D Seismic Survey.

### *Seabirds*

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

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

The risk of potential disruption to seabird behaviour by the Nikau 3D Seismic Survey is considered to be ***low*** (possible x negligible) on account of the potential temporary disturbance to feeding activities.

### *Marine Turtles*

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

In the unlikely event that a turtle is present in close proximity to the operating seismic vessel during the Nikau 3D Seismic Survey, some behavioural changes may occur; however, no specific mitigation measures are in place. Due to the unlikely occurrence of turtles in the Operational Area and the relatively short-term nature of the survey (30 day duration), it is considered that the risk of seismic operations to marine turtles will be ***low*** (unlikely x minor).

### *Fish, Cephalopods and Fisheries*

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

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

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

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

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

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

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

It is likely that pelagic fish and cephalopods will avoid the immediate vicinity of any acoustic disturbance during the Nikau 3D Seismic Survey. These predicted distributional changes could in turn result in the short-term displacement of commercially valuable fish stocks from the acquisition area, leading to a potential increase in the effort required to locate viable stocks and maintain catch rates.

Acoustic disturbance to fish and cephalopods is therefore possible during the Nikau 3D Seismic Survey and will be minimised through the following mitigation measures:

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

Commercial fishers have been advised of the Nikau 3D Seismic Survey and will be informed of the predicted start date and schedule closer to the time. With these mitigation measures in place it is considered that the risk of behavioural disruptions to fish and cephalopods and the consequences to fisheries during the Nikau 3D Seismic Survey is ***medium*** (likely x minor).

### *Crustaceans*

Although there is limited information on behavioural responses of crustaceans to acoustic disturbances, the following is a summary of the available literature.

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

The red rock lobster (commonly known as crayfish) is the most well-known and commonly harvested crustacean species in New Zealand and is important from a commercial, cultural and recreational perspective. They are found in coastal waters around New Zealand where rocky subtidal reefs are present. Commercial fishing for red rock lobster only extends out to the 12 Nm Territorial Sea and is concentrated on the eastern and southern coast of New Zealand (MFish, 2015b). As the Nikau 3D Seismic Survey will be acquired outside of the Territorial Sea, the effects on red rock lobster fisheries will be negligible.

Scampi and deep-water crabs (red crab, giant spider crab and two species of king crab) are also commercially harvested in New Zealand. Scampi are targeted by trawlers on grounds to the east of the North Island, the Chatham Rise, and the Auckland Islands, while the deep-water crabs are targeted by pots deployed in water depths up to 1,500 m (MFish, 2015c). As the Nikau 3D Seismic Survey is far from the scampi fishing grounds and in water depths shallower than those fished for deep-water crab, the survey will not impact on these fisheries.

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

#### 5.1.2.3 Potential perceptual effects on marine fauna

##### *Marine Mammals*

Marine mammals utilise sound to inform a range of behaviours such as foraging, navigation, communication, reproduction, parental care, and avoidance of predators, and to gain an overall awareness of the surrounding environment (Thomas *et al.*, 1992; Johnson *et al.*, 2009). The ability to perceive biologically important sounds is therefore crucial to marine mammals. Anthropogenic sounds produced in the same frequency as biological sounds could interfere with biologically important signals; an effect referred to as 'masking' (Richardson *et al.*, 1995; Di Iorio & Clark, 2009). The frequencies of marine mammal vocalisations (for communication and echolocation) relevant to the Nikau 3D Operational Area are presented in **Table 21**.

**Table 21: 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

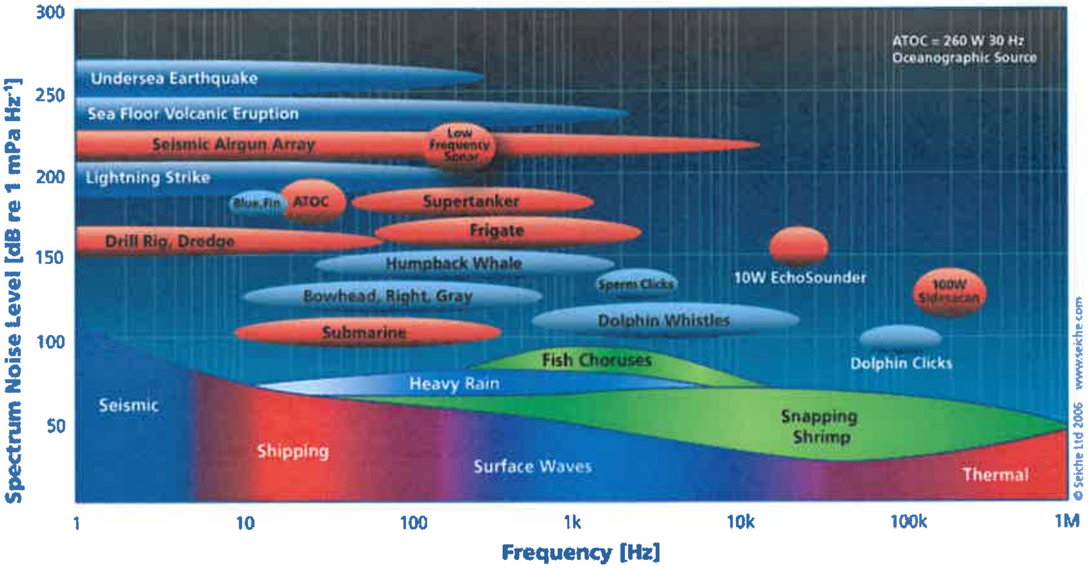
Cetaceans are broadly separated into three functional hearing groups (Southall *et al.*, 2007):

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

The sound frequencies emitted by seismic acoustic sources are broadband, with the majority of energy concentrated between 0.1–0.25 kHz. Therefore, the greatest potential for a seismic source to interfere with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum. This means that the lowest frequency cetaceans (i.e. southern right, minke, sei, humpback, blue and fin whales) are likely to be most affected by 'masking' as the seismic acoustic source has the greatest potential to overlap with these low frequency vocalisations (**Figure 27**). Vocalisations of mid and high frequency cetaceans are less likely to be masked.

Adaptive responses to anthropogenic underwater noises have also been documented, such as changes in vocalisation strength, frequency, duration and timing (McCauley *et al.*, 1998; Lesage *et al.*, 1999; McCauley *et al.*, 2003; Foote *et al.*, 2004; Nowacek *et al.*, 2007; Di Iorio & Clark, 2009; Parks *et al.*, 2011; McGregor *et al.*, 2013). For example, the calls emitted by blue whales during social encounters and feeding increased when a seismic survey was operational nearby (Di Iorio & Clark, 2009). Such adaptations are thought to increase the probability that communication calls will be successfully received by reducing the effects of masking (McGregor *et al.*, 2013).

**Figure 27: Overlap of ambient and localised noise sources in the ocean**



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

Masking of baleen whale calls is possible for seismic surveys in Taranaki waters; however, these effects will only persist for the 30 day duration of the survey. Hence, the risk of auditory masking of marine mammal vocalisations by the Nikau 3D Seismic Survey is considered to be ***medium*** (possible x minor).

### *Fish*

Some fish species use sound for communication, especially when alarming conspecifics of danger or during reproductive activities (DOSITS, 2016). Anthropogenic noise may interfere with such communication, for instance boat noise was found to mask acoustic communications in three vocalising fish species from the Adriatic Sea (Codarin *et al.*, 2009). Little is known about the vocalisations of New Zealand fish, but globally, approximately 800 species from over 100 families are known to produce sound (Ladich & Fine, 2006); hence it is reasonable to expect that sound has an important function for at least some New Zealand species. It is therefore assumed that there is a ***medium*** (possible x minor) risk of auditory masking for fish during the Nikau 3D Seismic Survey.

### 5.1.2.4 Potential physiological effects on marine fauna

### *Marine mammals*

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

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

The Code of Conduct sets thresholds that predict the physiological effects on marine mammals in New Zealand waters during seismic surveys based on those presented in Southall *et al.* (2007). The physiological threshold (or 'injury criteria') is exceeded if marine mammals are subject to SELs greater than 186 dB re 1 µPa$^2$-s (DOC, 2013) which corresponds to the SEL at which temporary threshold shifts may start to occur. The Code of Conduct requires that seismic operators employ mitigation measures specifically designed to minimise the potential for marine mammals to be subject to SELs that have the potential to cause threshold shifts (both permanent and temporary). Compliance with the Code of Conduct's mitigation measures and stipulated thresholds is the fundamental way in which OMV intends to minimise the potential of physiological damage to marine mammals during the Nikau 3D Seismic Survey.

STLM results indicate that the standard mitigation zone of 200 m will be sufficient to protect marine mammals from physiological disturbance during the Nikau 3D Seismic Survey. As per the Code of Conduct requirements, OMV 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.

If, for some unpredicted reason, the physiological thresholds for individual marine mammals are exceeded during the Nikau 3D Seismic Survey, temporary threshold shifts may result. Permanent threshold shifts are unlikely due to the typical avoidance behaviours exhibited by marine mammals (see **Section 5.1.2.2**) and compliance with the Code of Conduct (i.e. pre-start observations, soft start and shut-down procedures) which serve to minimise the risk to marine mammals to as low as reasonably practicable.

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

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

***Seabirds***

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

***Fish***

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

Scholik and Yan (2002) reported that a hearing threshold shift in fathead minnows was directly correlated to the sound frequency and the duration of exposure. A temporary threshold shift was observed after one hour of exposure to white noise at >1 kHz, but no threshold shift occurred at 0.8 kHz. Popper *et al.* (2005) observed varying degrees of threshold shifts in northern pike, broad whitefish, and lake-chub when exposed to a 730 $in^3$ acoustic source, and although the degree of threshold shift varied, all species recovered within 24 hours of exposure. The Nikau 3D Seismic Survey will use a 3,260 $in^3$ acoustic source with a frequency between 2 and 250 Hz. Emissions will occur every 8 seconds during acquisition.

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

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

Woodside (2007) conducted a comprehensive investigation to assess the effects of a seismic survey on reef fish in Western Australia. Water depths within the study area ranged from 20–1,100 m and the seismic source had a total capacity of 2,005 $in^3$. The study assessed a number of parameters including fish diversity and abundance, coral health, and any pathological changes to auditory tissues. Sound loggers and remote underwater video was deployed and fish exposure cages were utilised to contain captive reef fish. No temporary or permanent threshold shifts were documented for any species during this study.

During the Nikau 3D Seismic Survey there is potential for the acoustic source to induce temporary physiological effects on fish species that are in close proximity to the acoustic source; however, the risk of any lasting physiological effects are considered to be ***low*** (unlikely x minor) as most pelagic fish are predicted to move away from and avoid the greatest SELs.

### *Cephalopods*

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

Squid are found over the continental shelf in waters up to 500 m deep, but are most prevalent in water depths less than 300 m (MFish, 2014). Given this pelagic lifestyle, there is the potential for squid to come into close proximity to the acoustic source during the Nikau 3D Seismic Survey. Squid can readily move away from the highest SELs, therefore the duration of exposure during the survey is expected to be low. In addition, squid species are generally short-lived, fasting growing, and have high fecundity rates (MFish, 2014); these life history traits indicate that they are well adapted to disturbances. As a result, there are no anticipated long-term risks to squid populations.

Octopus species inhabit both coastal and offshore waters; some species inhabit reefs, while others can be found over soft sediment. Those species that prefer reef habitat tend to be primarily coastal species (e.g. *Octopus maorum*) and are likely to have higher site fidelity than open water species which are more likely to move away from disturbance. The offshore nature of the Nikau 3D Seismic Survey will reduce the exposure of coastal reef dwelling species to underwater noise.

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

### *Crustaceans and Molluscs*

Research has shown that some species of crustaceans and molluscs (scallop, sea urchin, mussels, periwinkles, crustaceans, shrimp, gastropods) suffer very little mortality below sound levels of 220 dB re 1µPa@1m, while some show no mortality at 230 dB re 1µPa@1m (Royal Society of Canada, 2004). Based on the STLM results for the Nikau 3D Seismic Survey, sound levels of this intensity (above 210 dB re 1µPa.$s^{-2}$) would only be reached in very close proximity to the acoustic source (i.e. within approx. 10 m).

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

Based on these results, and the fact that the shallowest water depth throughout the Operational Area is approximately 114 m, it is considered that the risk of physiological effects to crustaceans and molluscs will be ***low*** (likely x negligible).

### *Deep-water Benthic Communities*

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

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

In New Zealand, deep-water corals (e.g. black coral and stylasteroid hydrocorals) are generally found at depths greater than 200 m (see **Section 4.2.2**). Mortality of coral larvae is known to occur within 5 m of an acoustic source (DIR, 2007). However, black coral are protected from such close contact as their larvae are negatively buoyant and do not disperse very far from their parent colony (Parker *et al.*, 1997; Consalvey *et al.*, 2006).

The information above, coupled with the lack of coral fields in the North Taranaki region (see **Section 4.2.2**), suggests that deep-water coral communities are unlikely to be significantly affected by the Nikau 3D Seismic Survey. It is therefore predicted that noise from the Nikau 3D Seismic Survey will pose a ***low*** (unlikely x negligible) risk to deep-water corals.

### *Planktonic Larvae*

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

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

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

The effect of seismic surveys on larval settlement rates is of commercial interest. Knowledge of the timing of larval settlement can help with predicting potential effects. For example, the primary settlement phase for New Zealand rock lobsters is late winter/spring (Forman *et al.*, 2014); hence little temporal overlap is predicted between settlement and seismic operations during the Nikau 3D Seismic Survey.

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

### 5.1.3 Waste discharges/emissions

During the Nikau 3D Seismic Survey, the survey vessels will produce the following forms of waste:

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

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

#### 5.1.3.1 Potential effects from biodegradable waste

Biodegradable waste discharged during the Nikau 3D Seismic Survey will include: sewage, greywater, galley waste, and oily water. Upon discharge to the marine environment, this waste will undergo a decomposition process. This has two consequences. Firstly, oxygen in the surrounding area is used by the bacteria involved break down of the waste. Secondly, two main by-products, nitrogen and phosphorus are introduced into the environment. As a result, oxygen can become limited for other marine organisms especially in areas of low flow and mixing; and the enrichment in phosphorus and nitrogen can lead to algal blooms.

The survey vessels involved in the Nikau 3D Seismic Survey contain on-board sewage treatment plants that ensure a high level of treatment before any sewage or grey-water is discharged. Where applicable, vessels involved in the survey will also be required to hold an International Sewage Pollution Prevention Certificate.

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

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

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

The risk from routine discharges of biodegradable waste during the Nikau 3D Seismic Survey is considered to be ***low*** (likely x negligible).

#### 5.1.3.2 Potential effects from non-biodegradable waste

Discharges of solid non-biodegradable wastes to the marine environment can have severe detrimental effects on marine fauna, such as entanglement, injury, and ingestion of foreign objects. All non-biodegradable wastes produced during the Nikau 3D Seismic Survey will be returned to shore and disposed of in adherence to local waste management requirements, with all chain of custody records retained.

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

#### 5.1.3.3 Potential effects from atmospheric emissions

The principle source of atmospheric emissions during the Nikau 3D Seismic Survey is combusted exhaust gasses. Carbon dioxide makes up the large part of these emissions, although smaller quantities of other gasses such as oxides of nitrogen, carbon monoxide, and sulphur dioxide may also be emitted. Such emissions are classed as greenhouse gas emissions and are linked to climate change and reduce ambient air quality.

The survey vessels will hold International Air Pollution Prevention Certificates. This ensures that all engines and equipment are regularly serviced and maintained to minimise emissions.

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

### 5.1.4 Cumulative Effects

'Cumulative effects' during the Nikau 3D Seismic Survey may occur when multiple sources of underwater noise combine to significantly increase the overall underwater sound profile. Other seismic surveys and shipping traffic are of particular interest and are discussed below.

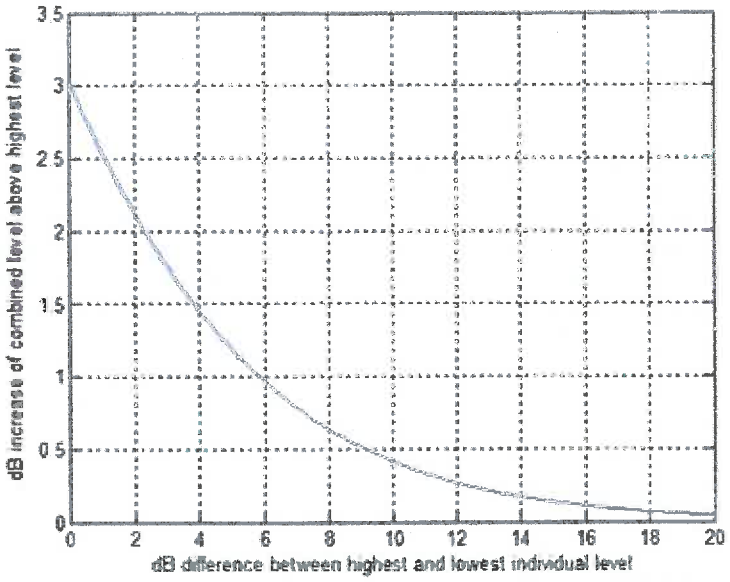
Few studies investigate cumulative effects in relation to seismic surveys; hence, any quantitative assessment of cumulative effects is extremely difficult. The calling rates of blue whales during a seismic survey were investigated by Di Iorio and Clark (2009) who concluded that the seismic survey was solely responsible for the observed changes despite the existing presence of shipping noise.

In an environment where substantial levels of shipping existed prior to any seismic operations, this pre-existing noise may not contribute to masking. However, in areas where shipping levels are lower, the combination of a seismic survey with shipping noise could result in greater disturbance to marine mammals than from either activity in isolation. In these circumstances, the zone of impact of masking effects could be relatively large given the low frequency nature of shipping and seismic noises which propagate over long distances. Offshore Taranaki is used on a frequent basis by large ships in transit. Hence shipping noise is considered an existing feature in offshore Taranaki waters. This may or may not contribute to masking for some species during the Nikau 3D Seismic Survey.

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

When the acoustic outputs from two difference seismic surveys combine, the outcome is counter-intuitive; the largest difference between the combined and individual SELs will be 3 dB re 1µP$^{2}$s, however this will only occur when both surveys produce an identical SEL. To put this into context, if at a given location Survey 'A' by itself would produce a SEL of 160 dB re 1µP$^{2}$s, and Survey 'B' by itself would also produce an SEL of 160 dB re 1µP$^{2}$s, then the two surveys combined will produce an SEL of 163 dB re 1µP$^{2}$s (Alec Duncan pers. comm.). However, if one survey produced a higher SEL, then the higher SEL would dominate to the point where if Survey 'A' produces an SEL of 6 dB re 1µP$^{2}$s higher than Survey 'B', then the combined level is 1 dB re 1µP$^{2}$s higher than the higher of the individual SELs (i.e. Survey A) (**Figure 28**).

**Figure 28: Combined Sound Exposure from Two Seismic Sources**



The potential for cumulative effects is greater when two surveys are operating close together in both time and space. It is hypothesised that a cetacean may be able to reorient and cope with a single sound source emitted from a seismic survey, but may be less able to cope with multiple sources.

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

OMV are currently unaware of any other seismic surveys that could potentially occur concurrently with the Nikau 3D Seismic Survey. However, they will reassess the potential for cumulative impact should they become aware of additional concurrent seismic operations as the planning for this survey progresses.

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

## 5.2 Unplanned Event – Potential Effects and Mitigations

Unplanned events associated with seismic surveys include: introduction of invasive marine species, streamer loss, hydrocarbons spills, or a vessel collision/sinking. The occurrence of unplanned events is low; however, the potential effects of these incidents can be serious which is why these potential effects should be given serious consideration.

### 5.2.1 Potential effects of invasive marine species

The introduction and spread of marine pests or invasive species to New Zealand waters can occur through ballast water discharges and fouling on sea chests and vessel hulls. Mitigation measures against the introduction of marine invasive species to the marine environment will be implemented for both the survey and support vessels. The seismic vessel will be inspected for the presence of invasive species by qualified inspectors prior to entering the country (this will most likely take place in Singapore). Measures will then be put in place in order to ensure that the vessels meet the Part 2.1 'Clean hull requirement' of the Craft Risk Management Standard – Biofouling on Vessels Arriving to New Zealand and the 'Import Standard for Ballast Water Exchange'.

On this basis, the potential risk of introducing invasive marine species during the survey is therefore considered to be ***low*** (rare x minor).

### 5.2.2 Potential effects from streamer loss

Damage or entanglement of towed gear (e.g. through snagging on floating debris, shark bites, abrasion, vessel collision) could result in streamers being severed and lost. As streamers are negatively buoyant, they will sink down the water column and there is potential for contact with the seabed

Solid streamers fitted with self-recovery devices will be used during the Nikau 3D Seismic Survey. The self-recovery devices are programmed to activate at a depth of approximately 50 m, bringing the severed portion back to the surface for retrieval. The use of self-recovery devices will minimise the potential for damage to the seabed and benthic communities in the event of streamer loss.

The Nikau 3D Seismic Survey will also be undertaken by experienced personnel, therefore the environmental risk from streamer loss is considered to be ***low*** (possible x negligible).

### 5.2.3 Potential effects from hydrocarbon spills

Refuelling at sea, leakages from storage or equipment, or a hull/fuel tank failure could all lead to a hydrocarbon spill. If a spill from the fuel tank of the seismic vessel did occur, the maximum possible volume spilt would be (2092) m³.

Hull or fuel tank failure would require a complete failure of the vessel's fuel containment systems or catastrophic failure of hull integrity. Multiple measures are in place to ensure that the risk of this happening is minimized: the high-tech navigational systems on-board, adherence of the COLREGS and operational procedures aligned with international best practice.

Of these scenarios, a refuelling incident at sea is the most likely to cause of a hydrocarbon spill during a Seismic Survey. Scenarios which would lead to fuel spills include hose ruptures, coupling failures and tank overflows. However, spills caused by fuel handling mishaps are rare due to well-tested monitoring and management systems. Refuelling at sea is unlikely to be required during the Nikau 3D Seismic Survey on account of the relatively short duration of the survey; however, should refuelling at-sea occur, the *PGS Apollo* has a detailed refuelling protocol and procedures are in place to prevent any incidents.

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

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

- Refuelling will only be undertaken during daylight hours 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 before each fuel transfer;
- Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas and refuelling areas;
- Refuelling operations will be continuously manned to ensure constant visual monitoring of gauges, hoses, fittings, and the sea surface; and
- Radio communications will be maintained between the seismic vessel and support vessel.

In the event that a spill occurs during refuelling, a spill response will initially be undertaken in accordance with the Shipboard Oil Pollution Emergency Plan, and notification will be provided to Maritime New Zealand and local authorities (i.e. Taranaki District Council) as required.

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

### 5.2.4 Potential effects from vessel collision or sinking

If a collision occurred during the seismic operations, the biggest threats to the environment would be the vessel reaching the sea floor and/or the release of any hazardous substances or hydrocarbons (see **Section 5.2.3**). 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. In addition, efforts have been made to ensure all other marine users are aware of the presence of the seismic vessel. As a result, the risk of a vessel collision or sinking incident is considered to be ***low*** (rare x moderate).

## 5.3 Environmental Risk Assessment Summary

A summary of the ERA results is presented in **Table 22**.

**Table 22: Summary of ERA Results for the Nikau 3D Seismic Survey**

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

# 6 ENVIRONMENTAL MANAGEMENT PLAN

The management of environmental risks is fundamental to OMVs operating philosophy. The protocols outlined in the MMMP (**Appendix D**) are the primary measures by which OMV proposes to manage environmental risks during the Nikau 3D Seismic Survey. The MMMP is the operating procedure that is followed by MMOs and the seismic vessel crew while at sea in order to ensure compliance with the Code of Conduct.

Some additional measures over and above the requirements of the Code of Conduct will also be in place during the Nikau 3D Seismic Survey. As well as being reflected in the MMMP, these measures are summarised in the Environmental Management Plan (EMP) presented in **Table 23**.

The EMP is essential for the successful implementation of the Nikau 3D Seismic Survey. It summarises the key environmental objectives, the full suite of mitigation measures, and the regulatory and reporting requirements and commitments outlined in this MMIA.

**Table 23: Nikau 3D Seismic Survey Environmental Management Plan**

| Environmental Objectives | Proposed Controls | Relevant Legislation or Procedure |
|---|---|---|
| Minimise behavioural and physiological effects to marine fauna | • The limited duration of operational activities serves to reduce the temporal scale of impacts to an anticipated 30 days<br>• Seismic operations will continue around the clock (where possible) to reduce the overall duration of the survey<br>• The slow speed (4-5 knots) of the seismic vessel will reduce the potential for collisions with marine fauna<br>• The summer survey timing is not predicted to significantly affect baleen whale migration behaviours<br>• All seismic operations outside 12 nm, hence effects on coastal species & larvae will be minimised<br>• OMV has undertaken source modelling to ensure that their survey is using the lowest possible acoustic source volume<br>• Compliance with the Code of Conduct, including:<br>➢ Visual and acoustic detections of marine mammals to prompt required delayed starts and shut-downs<br>➢ Soft starts to ensure that mobile fauna can avoid the highest SELs<br>➢ Adherence to an approved Marine Mammal Mitigation Plan<br>➢ STLM has been conducted to assess the appropriateness of standard mitigation measures in the Code of Conduct<br>➢ A larger than standard mitigation zone has been proposed based on the STLM results: 1,500 m for Species of Concern (with or without calves); and ground-truthing will occur during the survey<br>➢ PAM equipment has been approved as suitable for high frequency New Zealand Species of Concern (**Appendix E**)<br>• Marine mammal sightings will be collected whilst in transit to the Operational Area<br>• MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea<br>• MMOs to notify DOC immediately of any southern right whale, humpback whale or Hector's/Maui's dolphin sightings<br>• Weekly MMO reports to be provided to DOC and EPA<br>• OMV will consider covering the cost of necropsies on a case-by-case basis in the event of marine mammal strandings | Code of Conduct<br>EEZ Act 2012<br>MMMP |
| Minimise disruption to fisheries and other marine traffic | • The limited duration of operational activities serves to reduce the temporal scale of effects to an anticipated 30 days<br>• Seismic operations will continue around the clock (as possible) to reduce the overall duration of the survey<br>• Comply with the COLREGS and have a support vessel present at all times<br>• Notify commercial fishers of the proposed survey and provide web-based real-time position information and scheduling<br>• Issue a Notice to Mariners and a coastal navigation warning<br>• Display a tail buoy (with lights) at the end of each streamer to mark the overall extent of the towed equipment<br>• All seismic operations outside 12 nm, hence effects on recreational fish stocks species will be minimised | COLREGS<br>International best practice |
| Minimise effects on marine archaeology, cultural heritage, submarine infrastructure | • No planned activity will impact the seabed<br>• All seismic operations outside 12 nm, where most sites of cultural significance are located | RMA 1991 |
| Minimise potential of invasive species | • Survey vessels to be inspected by qualified invasive marine species inspectors<br>• Adherence to Craft Risk Management Standard for Vessel Biofouling (CRMS)<br>• Adherence to Import Health Standard for Ships Ballast Water (IHS) | Biosecurity Act 1993<br>IHS<br>CRMS |
| Minimise effects on water quality | • All discharges to sea will occur in accordance with MARPOL and relevant New Zealand legislation<br>• On-board sewage treatment plant and approved ISPPC as applicable<br>• On-board bilge water treatment plant to ensure oily water discharge does not exceed 15 ppm<br>• All non-biodegradable waste to be returned to shore for disposed at an approved shore reception facility<br>• OMV will ensure that a waste disposal log is maintained on all survey vessels | MARPOL Annex V and IV<br>Maritime Transport Act 1994<br>Marine Protection Rules Part 170<br>EEZ Discharge & Dumping Regulations 2015<br>Resource Management (Mar Pol) Regulations 1998 |
| Minimise effects on air quality | • Regular maintenance of machinery<br>• 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<br>• Comply with the COLREGS and have a support vessel present at all times<br>• Approved SOPEP and IOPPC where applicable to vessel class<br>• Refuelling (if required) will only occur during daylight and in good sea conditions, and will be constantly monitored<br>• Transfer hoses will be fitted with 'dry-break' couplings<br>• Spill response kits will be maintained and located in close proximity to hydrocarbon bunkering areas<br>• Radio communications will be maintained between the seismic vessel and support vessel during refuelling<br>• Solid streamers used in conjunction with self-recovery devices | International best practice<br>COLREGS<br>Maritime Protection Rules Part 130A and 123A<br>JHA for refuelling |

# 7 CONCLUSION

Marine seismic surveys are considered to be routine activities within the oil and gas industry and are a prerequisite for the discovery of hydrocarbons beneath the seabed. During the proposed Nikau 3D Seismic Survey, OMV will comply with the Code of Conduct as the primary means of mitigating environmental effects. In this instance STLM has indicated that a larger mitigation zone than standard is required to protect marine mammals from behavioural impacts; hence OMV has proposed to adopt a mitigation zone of 1,500 m to satisfy the behavioural threshold for Species of Concern with or without calves.

In compliance with the Code of Conduct, OMV will have two MMO's and two PAM operators on-board the seismic vessel. These personnel will be independent and qualified through DOC accredited training programmes. Visual observations will occur through daylight hours when the source is active and PAM operations to acoustically detect marine mammals will occur around the clock to enable detections of marine mammals at night. Depending on the circumstance and in keeping with the Code of Conduct, marine mammal detections will trigger the required mitigation actions, e.g. delayed start or shut downs of the source.

In addition to the measures outlined in the Code of Conduct, OMV will comply with all other relevant New Zealand legislation and international conventions (in relation to navigational safety, waste discharge, biosecurity etc.). OMV 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 Nikau 3D Seismic Survey and describes all proposed mitigation measures that will be implemented to ensure that any potential effects are reduced to levels as low as reasonably practicable.

Although the MMIA focusses largely on potential marine mammal effects, potential effects on other components of the marine ecosystem and existing maritime activities are also considered and assessed through well-established ERA methodologies. In summary, the predicted effects of the Nikau 3D Seismic Survey are considered to be ***low to medium***, with medium effects being sufficiently managed by the mitigation measures proposed in this MMIA.

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# Information Sheet
# Nikau 3D Seismic Survey

OMV New Zealand Limited

## Acquisition of 'Nikau' 3D seismic survey in the Taranaki Basin

- Acquisition of 1015 sqkm of 3D seismic data to investigate prospectivity.
- Survey will begin no earlier than 5th November.
- Duration of the survey is expected to be between 20 and 30 days.

## Introduction

OMV New Zealand Ltd (OMV) is preparing a Marine Mammal Impact Assessment (MMIA) for a marine seismic survey in the North Taranaki Basin. The Operational Area for the 'Nikau 3D Seismic Survey' is illustrated in **Figure 1**. The purpose of this survey is to investigate the underlying geology in Petroleum Exploration Permits 57075 and 60092 granted to OMV by New Zealand Petroleum and Minerals (Ministry of Business, Innovation and Employment) in 2015. The Operational Area is located within New Zealand's Exclusive Economic Zone, but seismic acquisition will not occur within the 12 nautical mile Territorial Sea. The proposed survey is scheduled to commence in November 2016, with an estimated total duration of up to 30 days.

OMV will operate in accordance with the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) which classifies Seismic Surveys as Permitted Activities as long as they comply with the Department of Conservation's *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Operations* (Code of Conduct).

## Operational Summary

Seismic surveying is commonly used in the oil and gas industry to improve the understanding of subsurface geology. The proposed survey will use a modern seismic survey vessel, towing an acoustic source array and hydrophone cables (streamers) to collect approximately 1,000 $km^2$ of seismic data.

The vessel will tow up to 10 streamers that will extend approximately 8 km behind the vessel. Streamers will be spaced at 150 m intervals, resulting in an overall span of up to 1,350 m. This broad span of towed gear significantly restricts the manoeuvrability of the vessel (**Figure 2**). The end of each streamer is marked with a tail buoy equipped with a flashing light and radar reflector, allowing the streamers to be visible day and night. The vessel will traverse a series of pre-determined survey lines within the Operational Area at a speed of approximately 4 – 5 knots (7 – 9 km/hr) and will operate 24 hours per day.

The source array produces acoustic emissions that are reflected off the subsurface geology and detected by the streamers on their return (**Figure 3**). These acoustic reflections (seismic data) are transferred back to the seismic vessel and are subsequently processed to provide information about the structure and composition of the geological formations below the seabed.

INFORMATION SHEET

Two support vessels will accompany the seismic vessel to ensure the survey area is clear of obstructions and to inform other marine users of the seismic vessel and its restricted ability to manoeuvre. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising others that a seismic survey is underway. These notices will be in place for the duration of the survey.

**Environmental Management and Approvals**

The proposed Nikau 3D Seismic Survey is undergoing comprehensive environmental risk assessments and risk mitigation planning. OMV will operate their proposed survey in accordance with the Department of Conservation's Code of Conduct as per the requirements of the EEZ Act. This requires a Marine Mammal Impact Assessment (MMIA) to be prepared and for the mitigation measures outlined in the Code of Conduct to be adhered to at all times to reduce the potential for any adverse effects on the marine environment, in particular marine mammals. Formal sign-off of the MMIA from the Director-General of Conservation is required before the seismic survey can commence.

OMV will place a minimum of four Marine Mammal experts onboard the seismic vessel. These qualified and independent industry professionals will observe and monitor the presence of any marine mammals within the confines of the survey area and operating limitations of the survey vessel and towed equipment. Two of these experts (MMO's) will monitor visually during daylight hours and two of the other experts will monitor sonically, via a designated PAM (Passive Acoustic Monitoring) system. This is a system that detects marine mammals that are vocalizing, giving a highly accurate range and bearing of the mammals to ensure any operational restrictions continue to be maintained throughout the survey.

As illustrated in Figure 1, OMV has designed the survey to exclude the area of the exploration permit which falls within the West Coast North Island Marine Mammal Sanctuary.

**If you have any further questions or matters you would like to discuss or you would like any further information in regard to the proposed survey, please contact:**

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INFORMATION SHEET

**Figure 1: Nikau 3D Marine Seismic Survey (Operational Area in red)**

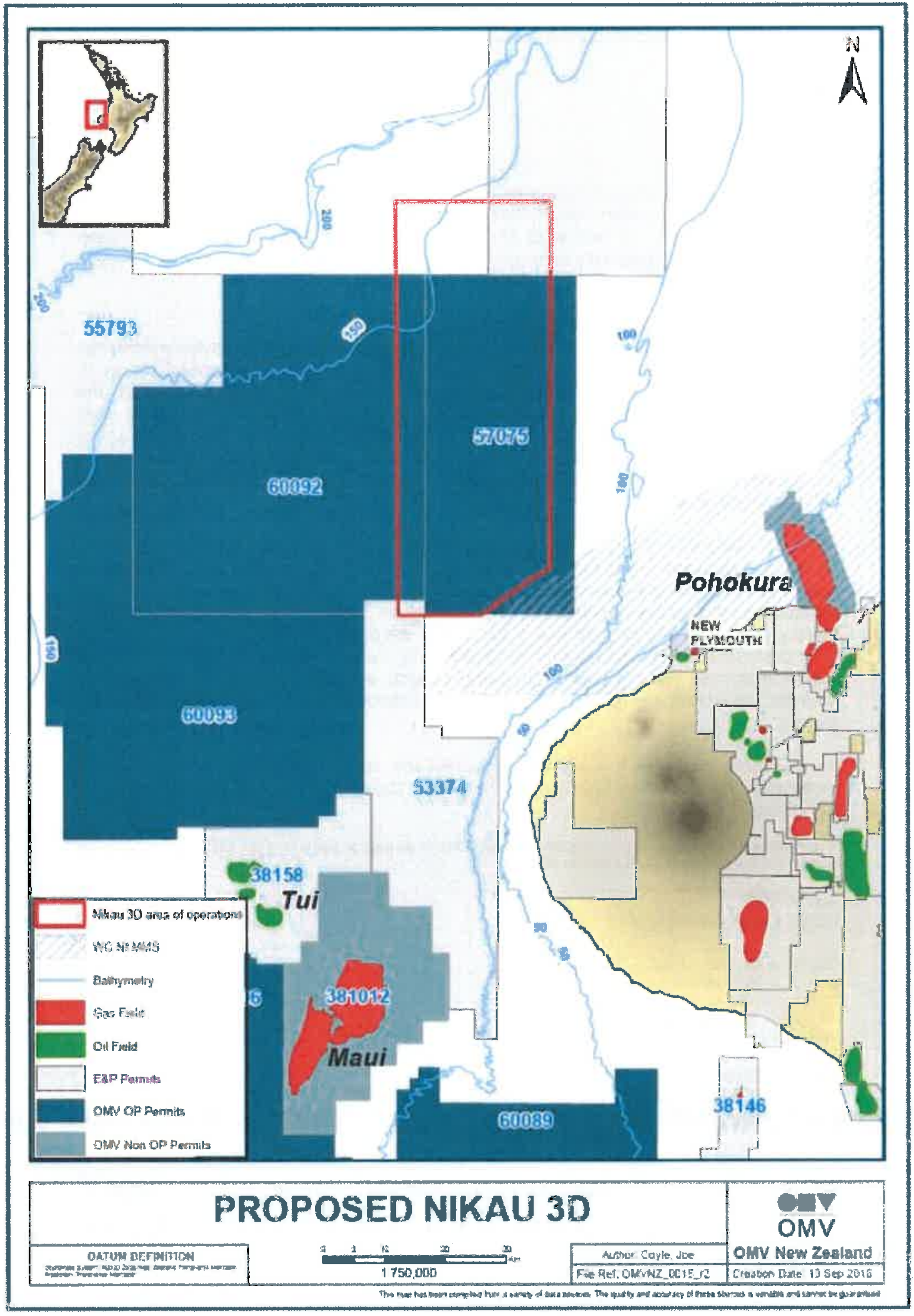
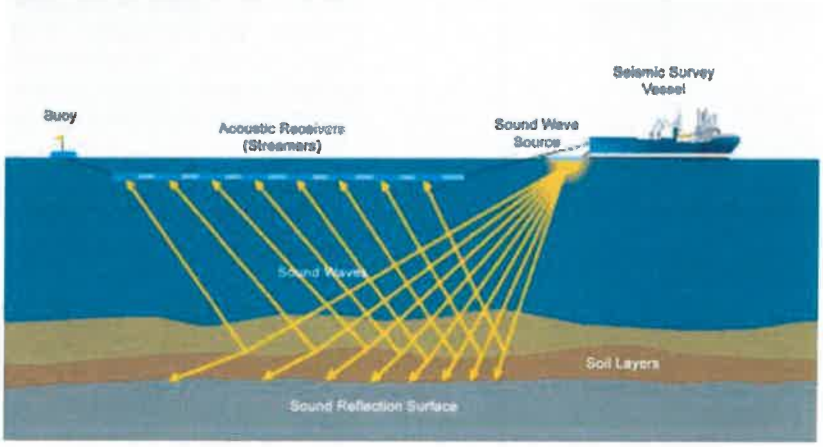


**Figure 2: Schematic of a 3D seismic survey layout**

**Figure 3: Schematic of acoustic sound waves being reflected from subsurface layers**



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| **Stakeholder** | **Means** | **Date** | **Feedback** |
|---|---|---|---|
| Department of Conservation - Taranaki | Meeting | 13.09.16 | DOC interested in any Maui's dolphin, humpback and southern right whale sightings, especially in the 12 Nm. OMV to provide details of vessel once selected. DOC Taranaki satisfied provisions of Code of Conduct will cover off local DOC concerns. |
| Manukorihi | Meeting | 13.09.16 | Manukorihi are generally opposed to the industry and do not want seismic surveys, but would like observers to be from the local area as this gives them more comfort. OMV offered potential assistance to Manukorihi environmental or community projects if a proposal is submitted. Initiatives and sponsorship provided by OMV is appreciated. |
| Ngati Mutunga | Meeting | 13.09.16 | Stated that the main concerns in the region are around the Marine Mammals Sanctuary and Maui's dolphins. Were glad to hear there is still some interest in the region/industry. OMV will provide an update on what they have done at Rotokare Scenic Reserve and what they will do over the next year. OMV to provide public link to MMIA once approved and will also supply the MMO report once completed. |
| Ngati Rahiri | Meeting | 13.09.16 | Voiced some concern about the fishing industry. Mary-Jane Waru is now a qualified MMO and is keen to be involved in the survey as well as get one of her own hapu to be trained. OMV to provide details of vessel once selected. An information sheet is to be provided and discussions about MMO provisions to continue once vessel details are known. |
| Ngati Tama | Meeting | 14.09.16 | Did not raise any specific concerns but discussions were had around OMV's operations/activities in the last year, potential for funding/sponsorship and potential contracts for local chase boat operators. |
| Taranaki Iwi Trust | Meeting | 14.09.16 | Taranaki Iwi Trust did not raise any concerns and were pleased with the visit and the update on operations and proposed survey. OMV to provide them with the information sheet and a summary sheet of OMV and what they do in the community. |
| Taranaki Regional Council | Phone Call | 14.09.16 | Spoke with the TRC about the proposed seismic survey. An overview of the survey and survey area was provided. TRC were comfortable with the survey as long as the survey was compliant with the Code of Conduct. |
| Deepwater Group | Email | 14.09.16 | An update was provided to the Deepwater Group on the proposed survey and an information sheet was provided showing the |

CONSULTATION REGISTER

| | | | |
|---|---|---|---|
| | | | survey area. Deepwater Group were going to pass on to Talleys and other relevant fishers, recommended contacting Sanfords. |
| Sanford Fisheries | Email | 15.09.16 | An update was provided to Sanfords on the proposed survey and an information sheet was provided. Sanford's were appreciative of the heads up on the survey. |
| Egmont Seafoods | Email | 20.09.16 | An update was provided to Egmont Seafoods on the proposed survey and an information sheet was provided. There was the potential that one fisher could be using the area and requested to have vessel contact details so they could liaise with the survey vessel during that time to avoid any conflict. |
| Maniapoto Maori Trust Board | Phone & Email | 7.09.16 | Request to meet with Maniapoto through phone and email. Mainapoto extended the invite out to the relative regional management committees to take OMV up on the meeting. However, after further email requests to come and visit there was no response so no meeting was held. |
| Otaraua Hapu | Email | 7.09.16 | An email invitation was sent out for a meeting when OMV were going to be in New Plymouth. However, the representative was out of the country at the time and requested that we email the relevant information through, which was done. |
| Port Taranaki | Email | 6.10.16 | An email with the Information Sheet was provided to Port Taranaki, indicating the likely timing of the survey and making OMV available if any other information is required. |
| New Plymouth Sportfishing and Underwater Club | Email | 6.9.10 | An email with the Information Sheet was provided to the New Plymouth Sportfishing and Underwater Club, indicating the likely timing of the survey and making OMV available if any other information is required. |
| Oregon State University | Email | 19.10.16 | An email with the Information Sheet was provided to Leigh Torres, whale researcher; indicating timing of the survey and making OMV available if any other information is required. |
| NIWA | Email | 19.10.16 | An email with the Information Sheet was provided to Kim Goetz, whale researcher; indicating timing of the survey and making OMV available if any other information is required. |
| Project Jonah | Email | 19.10.16 | An email with the Information Sheet was provided to Darren Grover; indicating timing of the survey. |

# Appendix C

Report Number 740.10013.00330

## SOUND TRANSMISSION LOSS MODELLING RESULTS

SLR

global environmental solutions

# Nikau 3D Seismic Survey

# North Taranaki Basin

# Sound Transmission Loss Modelling

Report Number 740.10013.AU330

4 October 2016

OMV New Zealand Ltd
Level 9, Deloitte House
10 Brandon Street, P.O. Box 2621
Wellington, New Zealand

Version: v1.0

# Nikau 3D Seismic Survey

# North Taranaki Basin

# Sound Transmission Loss Modelling

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## DOCUMENT CONTROL

| Reference | Status | Date | Prepared | Checked | Authorised |
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| 740.10013.AU330 | v1.0 | 4 October 2016 | Binghui Li | Dan Govier<br>Helen McConnell | Dan Govier |
| | | | | | |
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# Executive Summary

OMV New Zealand Ltd (OMV) has proposed to undertake a 3D marine seismic survey of approximately 1015 km$^2$ within the North Taranaki Basin (i.e. the 'Nikau 3D Seismic Survey'). SLR Consulting New Zealand Pty Ltd (SLR) has been engaged by OMV to provide a Marine Mammal Impact Assessment (MMIA) and the requisite Sound Transmission Loss Modelling (STLM) services for the proposed seismic survey, to assist OMV 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 a few kilometres from the array source location, in order to assess whether the proposed survey complies with the regulatory mitigation zone SEL requirements, and
- Long range modelling, i.e. prediction of the received SELs over a range of tens to hundreds of kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (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 'Nikau 3D Seismic Survey' is the Bolt 1900 LLXT 3260 cubic inch array. The array comprises two subarrays and each subarray has 11 active sources. The array has an average towing depth of 7.0 m and an operating pressure of 2,000 pounds per square inch (PSI). The array source modelling illustrates strong array directivity, particularly around the cross-line directions, 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 two sub-arrays.

The short range modelling prediction using worst case modelling conditions (i.e. spring sound speed profile and fine sand seabed half-space) demonstrates that the maximum received SELs over all azimuths are predicted to be below 186 dB re 1μPa$^2$·s at 200 m and below 171 dB re 1μPa$^2$·s at 1.5 km for the selected source location with a water depth of 114 m. However, the modelling results have shown that the maximum SELs are above 171 dB re 1μPa$^2$·s at 1.0 km, predominantly around the cross-line directions due to its extremely strong directivities.

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 West Coast North Island Marine Mammal Sanctuary has a minimum distance of approximately 5.5 km to the Operational Area. The maximum SELs received from the chosen source location with the closest distance to the sanctuary are predicted to be approximately 150 dB re 1μPa$^2$·S. The majority of the marine sanctuary areas within a 50 km distance from the source location between the south and the east direction have predicted received noise levels to be above 120 dB re 1μPa$^2$·S. For other marine sanctuary areas further than 50 km, the received noise levels are predicted to drop from 120 dB re 1μPa$^2$·S at the east-northeast direction to levels below 100 dB re 1μPa$^2$·S near the coastline within 200 km distance at the north-northeast direction.

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## APPENDICES

# 1 INTRODUCTION

## 1.1 Project description

OMV New Zealand Ltd (OMV) is proposing to undertake a 3D marine seismic survey of approximately 1015 km$^2$ within the North Taranaki Basin (i.e. the 'Nikau 3D Seismic Survey'). The Operational Area of the survey is illustrated in **Figure 1**.

SLR Consulting NZ Ltd (SLR) has been engaged by OMV 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).

**Figure 1 The Operational Area (in red) for the proposed 'Nikau 3D Seismic Survey'. Yellow polygons show the 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.

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.

## 1.3 Structure of the report

This STLM study includes the following three modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the array source, including its directivity characteristics;
- Short range modelling, i.e. prediction of the received SELs within a range of a few kilometres from the array source location, in order to assess whether the proposed survey complies with the near-field mitigation zone requirements imposed by the Code, and
- Long range modelling, i.e. prediction of the received SELs over a range of tens to hundreds of kilometres from the array source location, in order to assess the noise impact from the survey on the relevant far-field sensitive areas (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**.

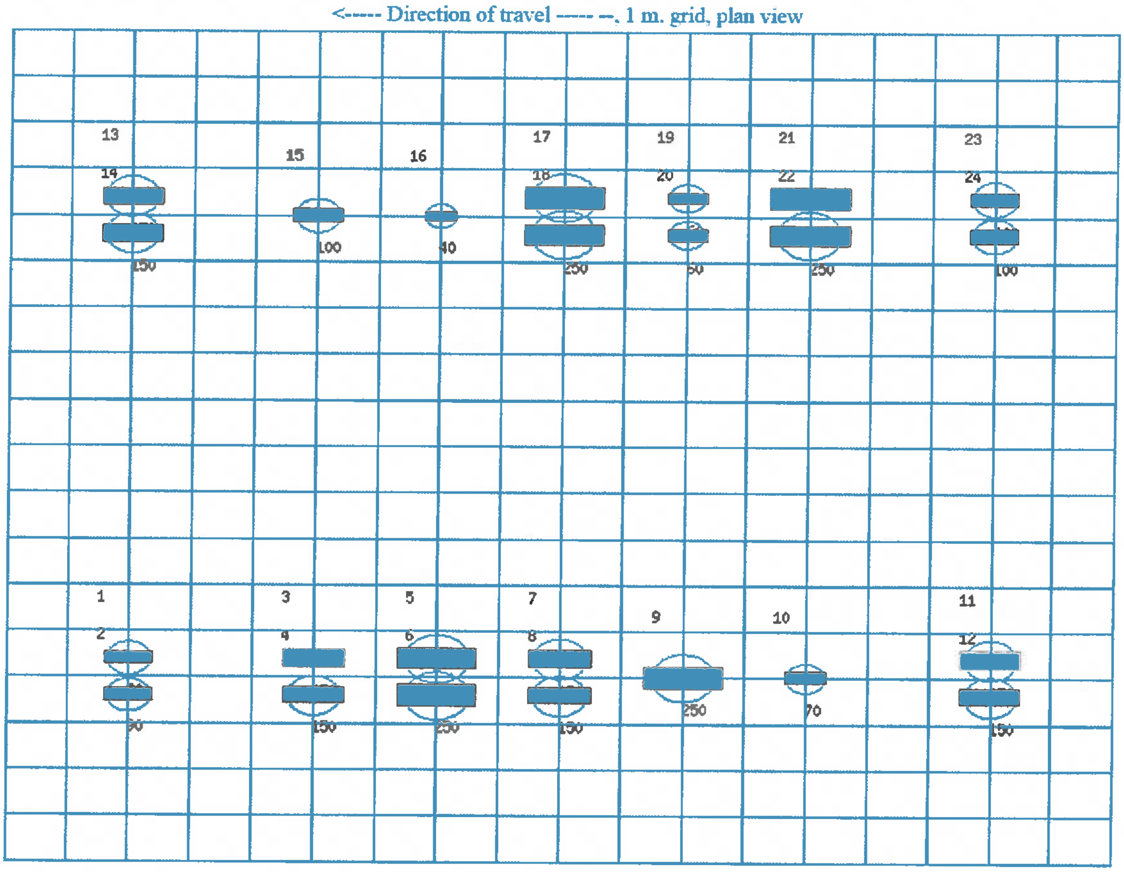
Relevant acoustic terminologies throughout the report are presented in **Appendix A**.

# 2 ACOUSTIC SOURCE ARRAY SOURCE MODELLING

## 2.1 Acoustic source array configuration

The acoustic source array that will be used for the seismic survey is the Bolt 1900 LLXT 3260 cubic inch array and its configuration is shown in **Figure 2**. The array comprises two sub-arrays, with each sub-array comprising 12 (11 active and 1 spare) acoustic source elements arranged as either single acoustic sources or in clusters. The array has an average towing depth of 7.0 m and an operating pressure of 2,000 pounds per square inch (PSI).

**Figure 2 The configuration (layout and volumes) of the Bolt 1900 LLXT 3260 cubic inch source array in a 1m-grid plan view. Active elements are in green color and spare elements in blue color.**



## 2.2 Modelling methodology

The required outputs of the acoustic source array source modelling for the subsequent sound modelling predictions include:

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

### 2.2.1 Notional signatures

The notional signatures are the pressure waveforms of each individual acoustic source, accounting for its interaction with other source element in the array, at a standard reference distance of 1 m.

Notional signatures are modelled using the Gundalf Designer software package (2016). The Gundalf acoustic source array source model is developed based on the fundamental physics of the oscillation and radiation of acoustic source bubbles as described by Ziolkowski (1970), taking into account non-linear pressure interactions between acoustic sources (Ziolkowski et al., 1982; Dragoset, 1984; Parkes et al., 1984; Vaages et al., 1984; Laws et al., 1988 & 1990).

The model solves a complex set of differential equations combining both heat transfer and dynamics, and has been calibrated against multiple measurements of both non-interacting acoustic sources and interacting cluster sources for all common acoustic source types at a wide range of deployment depths.

### 2.2.2 Far-field signatures

The notional signatures from all acoustic sources in the array are combined using appropriate phase delays in three dimensions to obtain the far-field source signature of the array. This procedure to combine the notional signatures to generate the far-field source signature is summarised as follows:

- The distances from each individual acoustic source to nominal far-field receiving location are calculated. A 9 km receiver set is used for the current study;
- The time delays between the individual acoustic sources and the receiving locations are calculated from these distances with reference to the speed of sound in water;
- The signal at each receiver location from each individual acoustic source is calculated with the appropriate time delay. These received signals are summed to obtain the overall array far-field signature for the direction of interest; and
- The far-field signature also accounts for ocean surface reflection effects by inclusion of the "surface ghost". An additional ghost source is added for each acoustic source element using a sea surface reflection coefficient of -1.

### 2.2.3 Beam patterns

The beam patterns of the acoustic source array are obtained as follows:

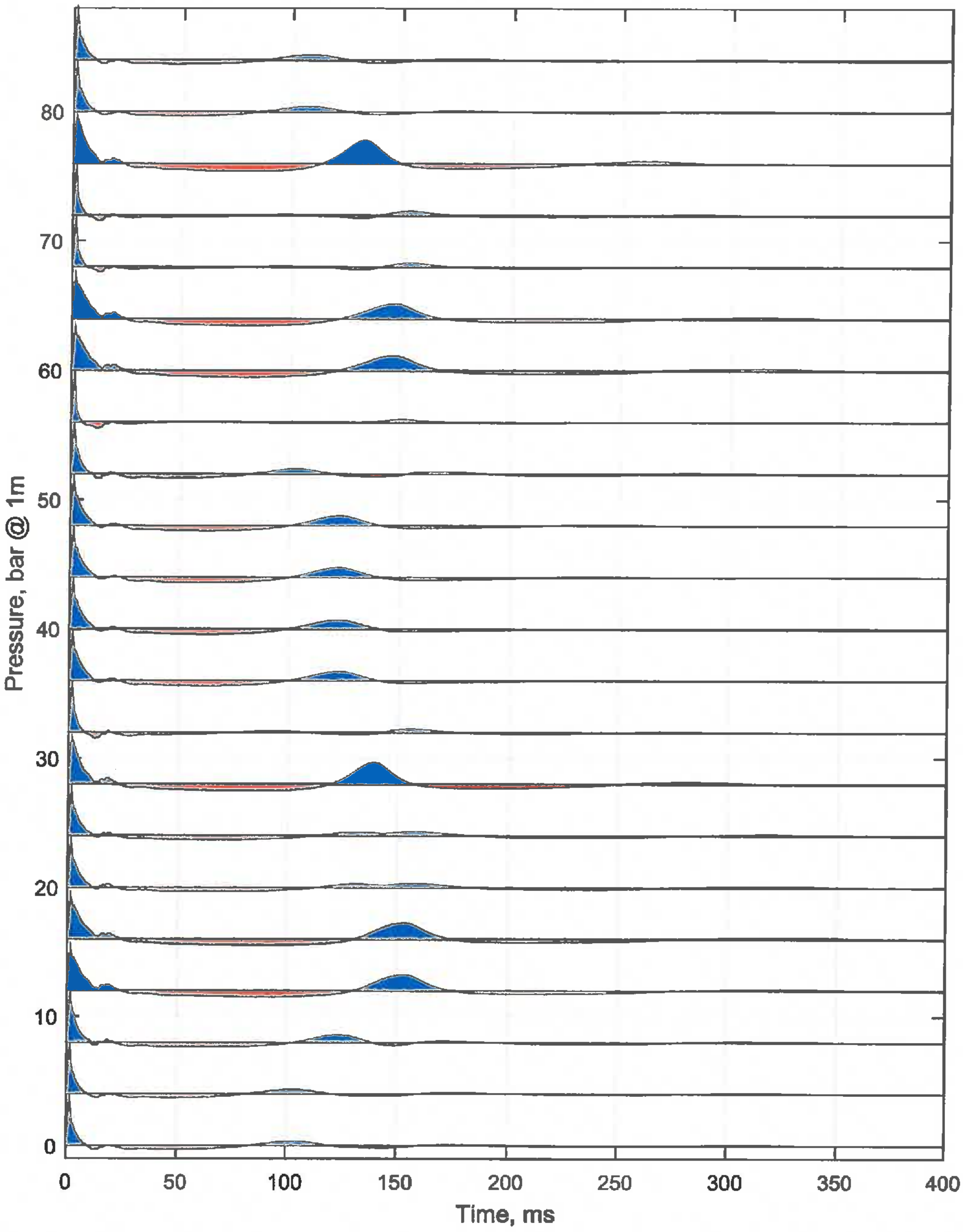
- The far-field signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The power spectral density (PSD) (dB re 1 $\mu Pa^2s/Hz$ @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of 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 22 active acoustic sources (11 active acoustic sources per sub-array) of the Bolt 1900 LLXT 3260 cubic inch array.

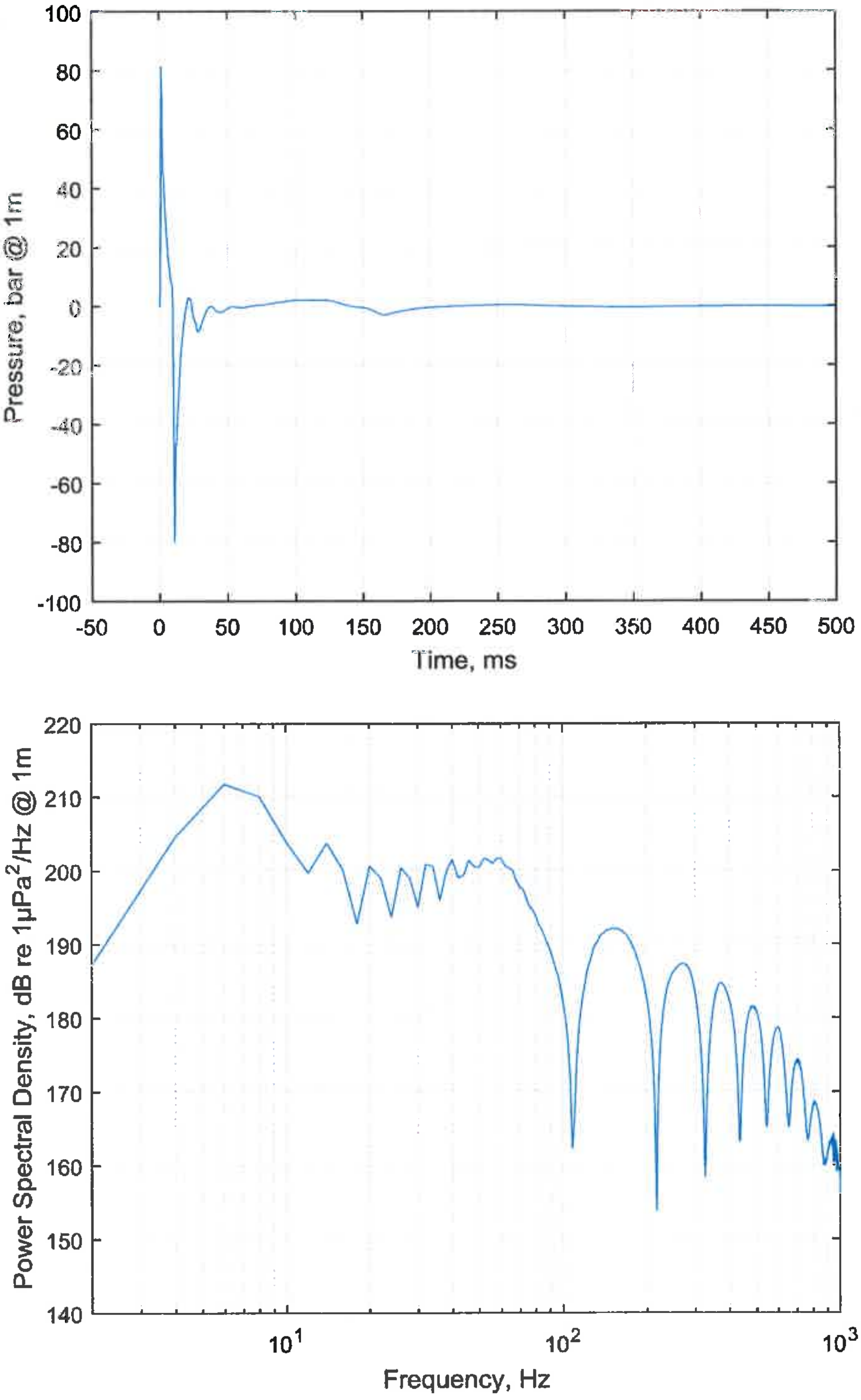
**Figure 3** Notional source signatures for each individual acoustic source element within the Bolt 1900 LLXT 3260 cubic inch array. Time series of positive pressure and negative pressure indicated by blue fill and red fill respectively. The relative pressure scale is the same for the signatures from all acoustic source elements.



### 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 Bolt 1900 LLXT 3260 cubic inch array.**



### 2.3.3 Beam patterns

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

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

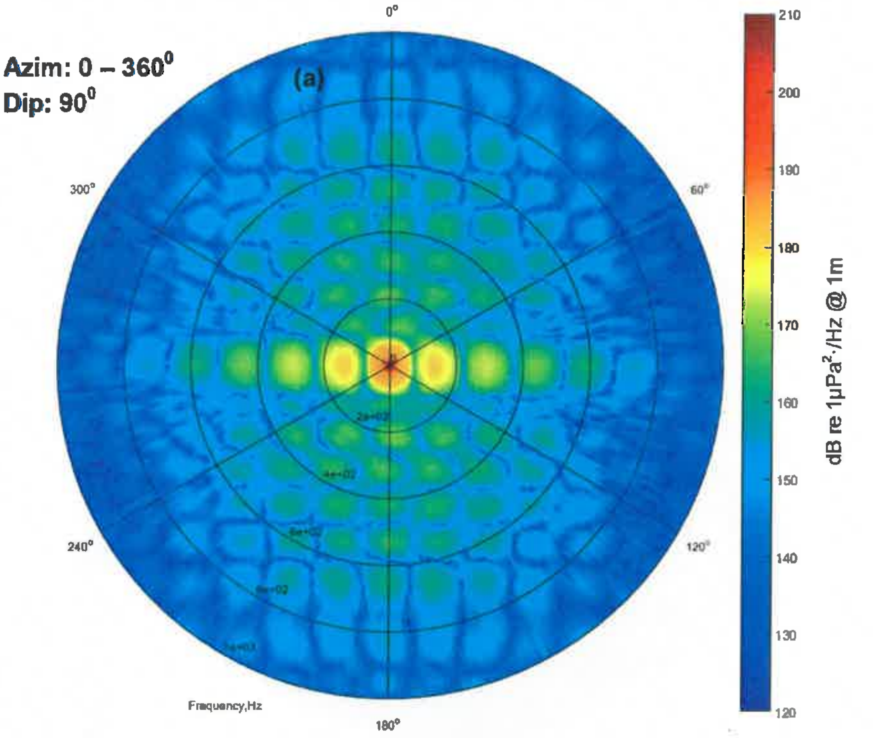
b) The vertical plane for the in-line direction (i.e. azimuthal angle of 0 degree) with dip angle of 0 degree corresponding to the vertically downward direction; and

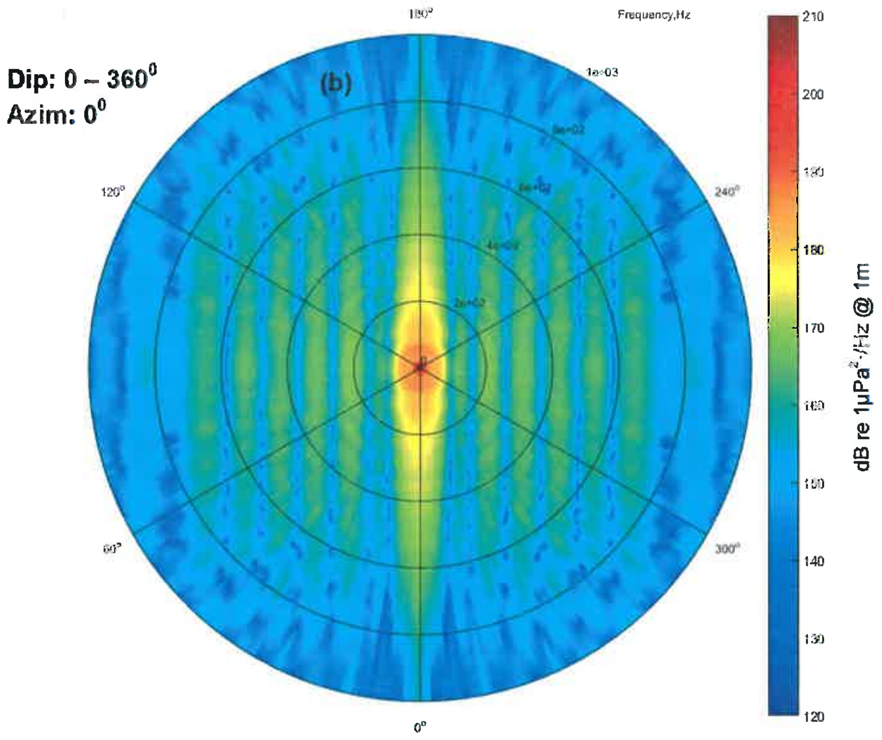
c) The vertical plane for the cross-line direction (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

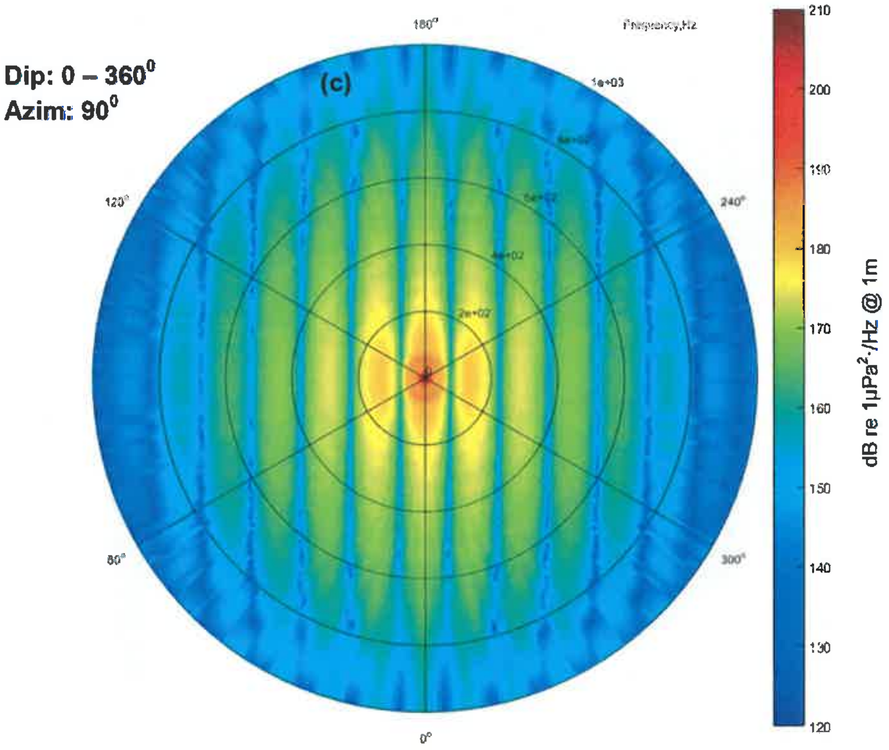
The beam patterns in **Figure 5** illustrate the strong angle and frequency dependence of the energy radiation from the array. The beam pattern of the horizontal plane shows much stronger energy radiation in the cross-line direction than in the in-line direction. The beam patterns of the in-line and cross-line vertical planes (particularly the cross-line 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 Bolt 1900 LLXT 3260 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 – 360⁰
Azim: 0⁰
(b)
180°
Frequency,Hz
1e+03
8e+02
6e+02
4e+02
2e+02
120°
240°
60°
300°
0°
210
200
190
180
170
160
150
140
130
120
dB re 1μPa²·/Hz @ 1m


Dip: 0 – 360⁰
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180°
Frequency,Hz
1e+03
8e+02
6e+02
4e+02
2e+02
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

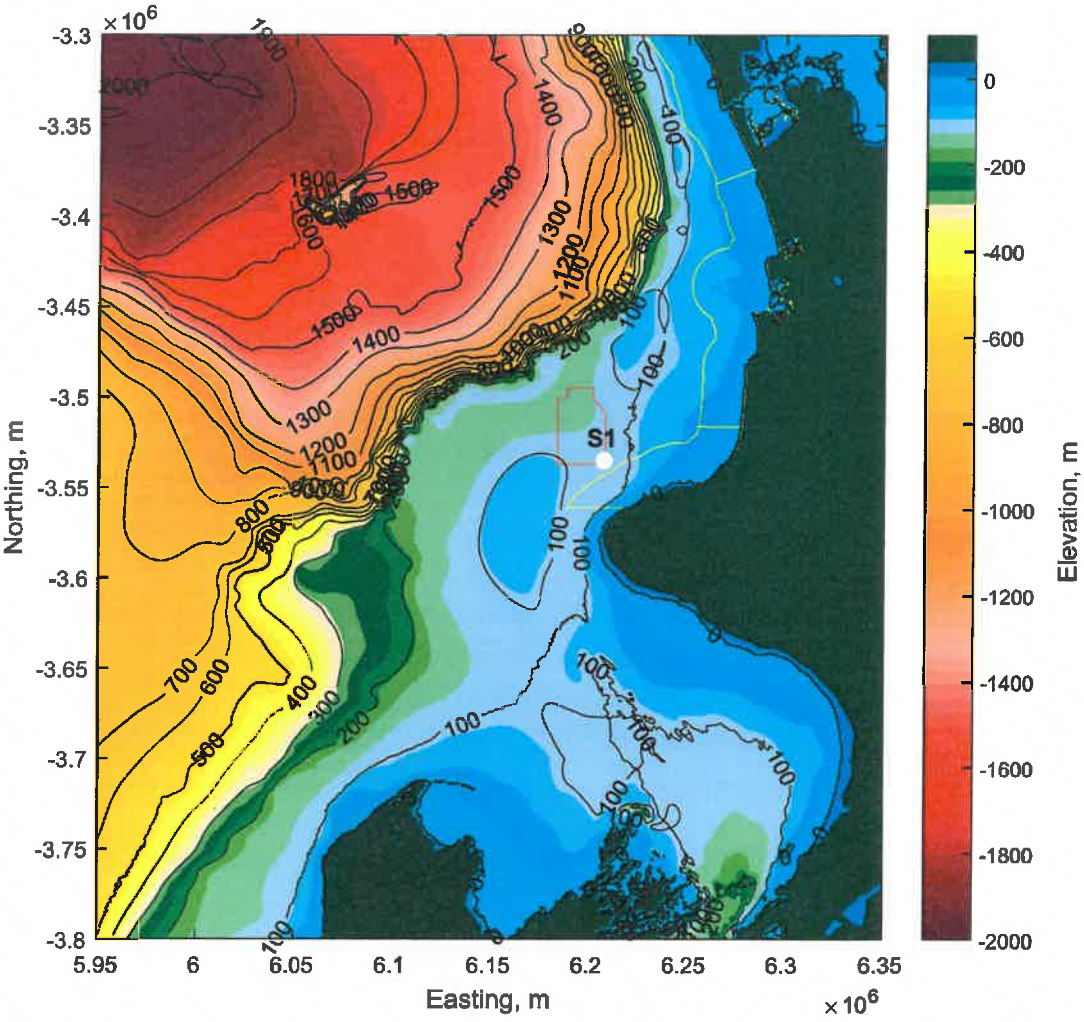
### 3.1.1 Bathymetry

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 modelling location S1 selected for both short and long range modelling cases was on the basis that this location represents the shallowest water depths within the Operational Area, as well as its proximity to the West Coast North Island Marine Mammal Sanctuary.

**Figure 6** **The bathymetric imagery in a resolution of 250 m covering the Operational Area. The coordinate system is based on map projection WGS 84 / Mercator 41. Yellow polygons show the marine mammal sanctuary and red polygons are the Operational Area boundaries. White dots (S1) indicate the selected source location for the short-range and long-range modelling cases.**



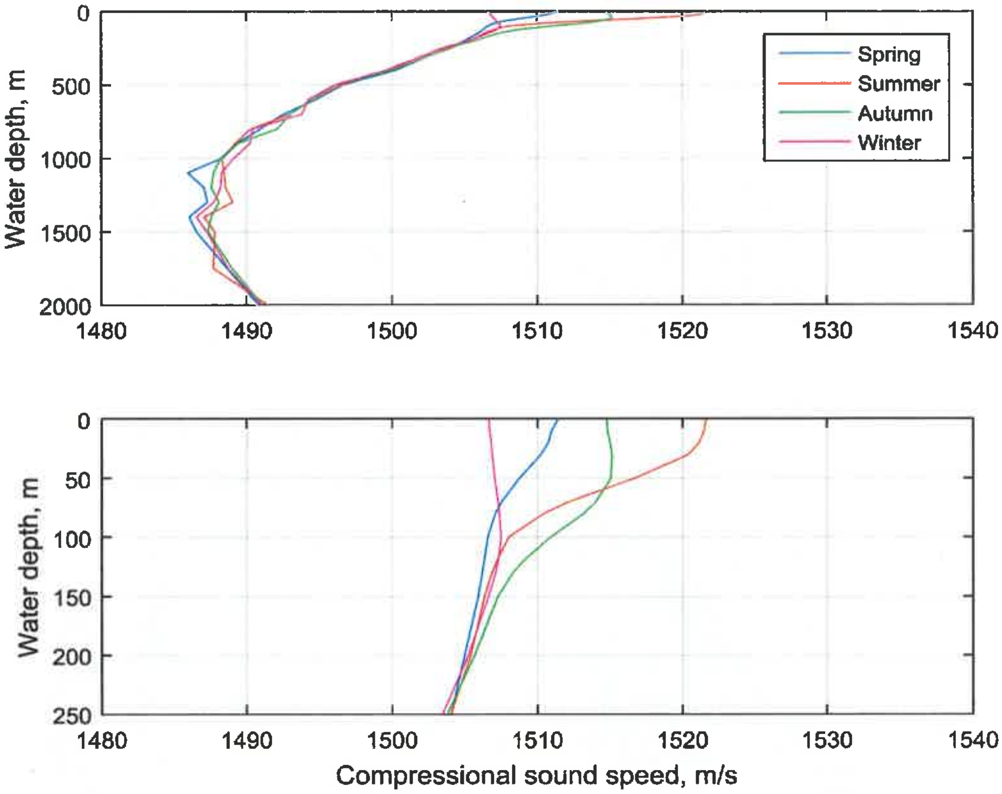
### 3.1.2 Sound speed profiles

Temperature and salinity data required to derive the sound speed profiles were obtained from the World Ocean Atlas 2009 (WOA09) (Locarnini et al., 2010; Antonov et al., 2010). The hydrostatic pressure used to calculate the sound speed based on depth and latitude of each particular modelling location was obtained using Sanders and Fofonoff's formula (Sanders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

**Figure 7** presents the typical sound speed profiles for four Southern Hemisphere seasons in close proximity to the Operational Area within the Taranaki Basin. The figure demonstrates that the most significant distinctions for the profiles of four seasons occur within the mixed layer near the surface. The spring and summer seasons have downwardly refracting near-surface profiles, with the summer profile having the stronger downwardly refracting feature. Both the autumn and winter seasons exhibit a surface duct, with the profile in the winter season having a stronger and deeper surface duct than that in the autumn season. Due to the stronger surface duct within the profile, it is expected that the winter season will favour the propagation of sound from a near surface acoustic source array. In descending order, the autumn, spring and summer seasons are expected to have relatively weaker sound propagation for a near-surface acoustic source array.

The proposed survey is scheduled to occur within a period of 20 – 30 days starting from November 2016. Therefore, the spring sound speed profile has been selected to provide the most conservative sound propagation modelling scenarios.

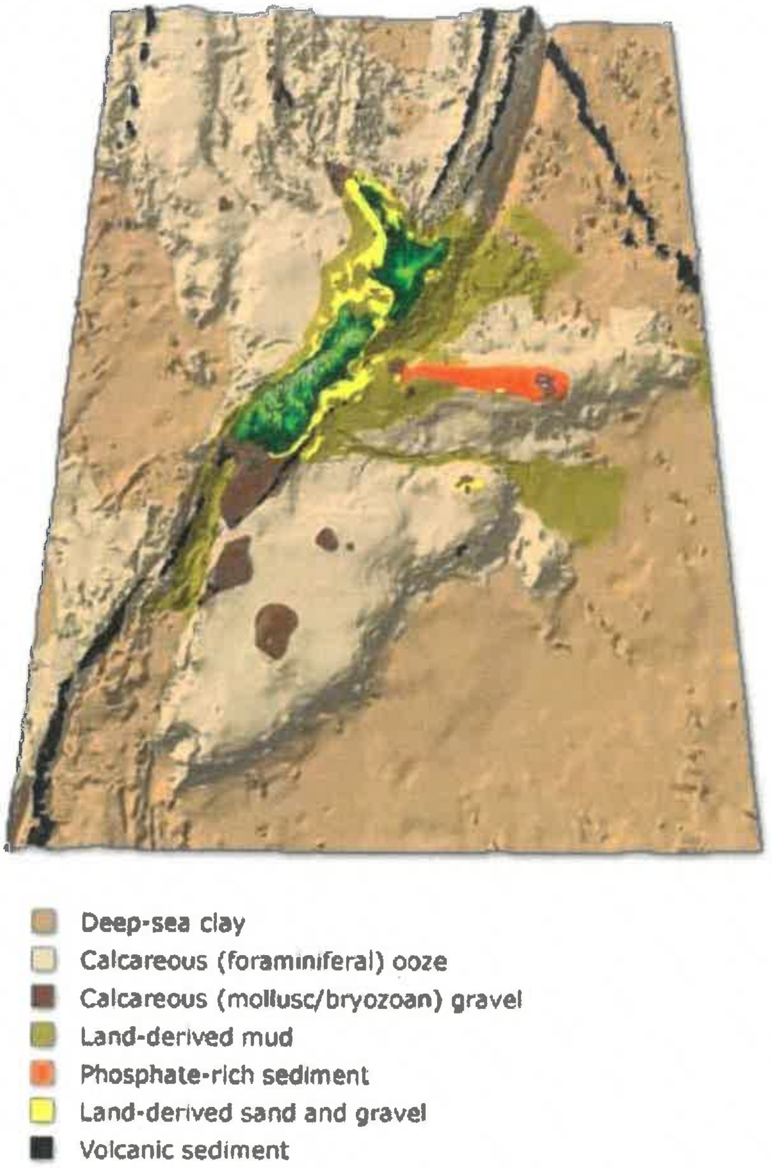
**Figure 7** **Typical sound speed profiles west of the North Island within Taranaki Basin for different Southern Hemisphere seasons. Top panel shows profiles in deep water region, bottom panel shows profiles in the continental shelf area.**



### 3.1.3 Seafloor geo-acoustic models

New Zealand has diverse seafloor sediments thanks to its variable and dynamic marine and terrestrial environments. NIWA has produced a variety of marine sediment charts illustrating the ocean bottom types around coastal New Zealand and some offshore areas. The map in **Figure 8** extracted from NIWA illustrates the distribution of the main types of marine sediments found on the ocean floor around New Zealand (Lewis et al., 2012 & 2013).

**Figure 8 The distribution of the main types of marine sediment on the seafloor within coastal and offshore regions around New Zealand**



The Continental shelf is covered mainly with land-derived sand, gravel and mud sediment, except at the northern and southern extremities where the shelly sediment from once-living sea creatures prevails due to the lack of major rivers. Within the project area, off the western North Island, areas of black iron-rich sand have been formed by wave action on volcanic rock and via riverine input from Mount Egmont.

The detailed sediment types for various relevant coastal and offshore regions are referred to in the NZ marine sediment charts and some technical reports (e.g. Matthew et al., (2014) and Galindo-Romero et al., (2014)). A summary of sediment types in and around the Taranaki Basin is provided in **Table 1**.

**Table 1 Detailed sediment types within the coastal and offshore regions west the North Island.**

| Region | | Sediment Type |
|---|---|---|
| West Coast North Island | 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 west and southwest of the North Island are presented in **Table 2**. The geoacoustic properties for sand, silt and clay are as described in Hamilton (1980), with attenuations referred to in Jensen et al., (2011). The elastic properties of sand, silt and clay are treated as negligible.

**Table 2 Geoacoustic properties for various possible sediment types within the coastal and offshore regions west of the North Island.**

| Sediment Type | Density, $\rho$, ($kg.m^{-3}$) | Compressional Wave Speed, $c_p$, ($m.s^{-1}$) | Compressional Wave attenuation, $\alpha_p$, ($dB/\lambda$) |
|---|---|---|---|
| **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)

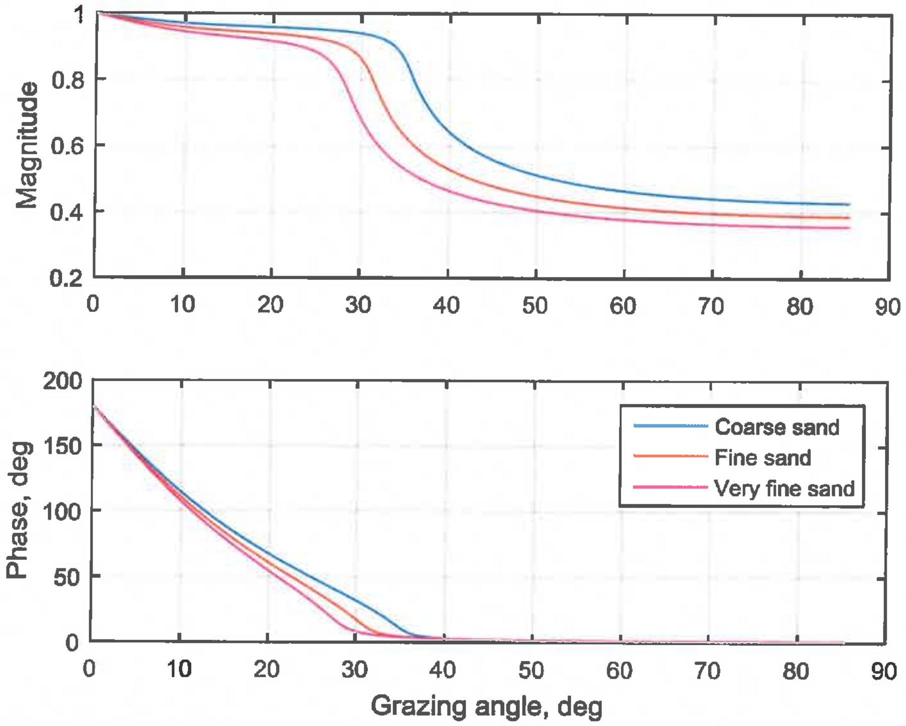
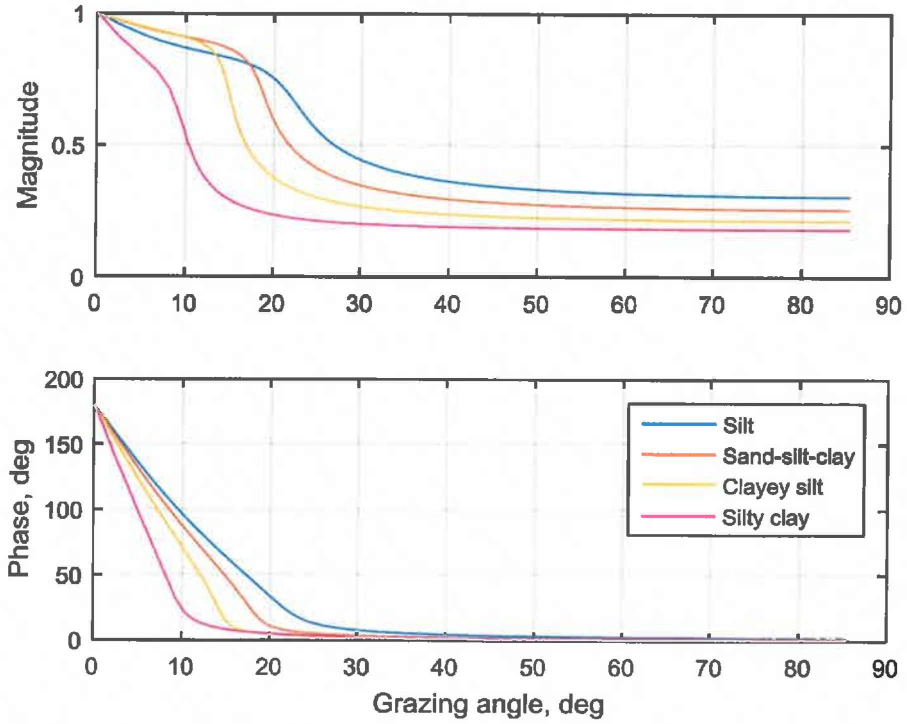


**Figure 10** The reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay)



## 3.2 Detailed modelling methodologies and procedures

The considerations for the achievable modelling accuracy, source directivity characteristics and computational cost of the short range and long range modelling cases are different. The following sections describe the different modelling methodologies and procedures employed for the short range and long range modelling cases.

### 3.2.1 Short range modelling

#### 3.2.1.1 Modelling methodology and procedure

The short range modelling is used to verify mitigation zones in relatively close proximity to the array source, and requires modelling predictions with high accuracy. In addition, interference between the signals arriving at any receiving location from different acoustic sources in the array is expected to be significant and complex for such a near-field scenario. To account for these considerations, the predictions for the short range case are modelled by reconstructing and adding the received signal waveforms from individual acoustic source units within the array. The wavenumber integration modelling algorithm SCOOTER (Porter, 2010) is used to calculate the transfer functions (including both amplitudes and phases) between sources and receivers. SCOOTER is a finite element code for computing acoustic fields in range-independent environments. The method is based on direct computation of the spectral integral, and is capable of dealing with an arbitrary layered seabed with both fluid and elastic characteristics.

The following procedure is followed to calculate received SELs:

1) The modelling algorithm SCOOTER is executed for frequencies from 1 Hz to 1 kHz, in a 1-Hz increment. The source depth of the Bolt 1900 LLXT 3,260 cubic inch array is 7.0 m. A 1-m receiver grid in both range and depth with a maximum range up to 4 km is applied for the selected source 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 element in the array to each receiver is calculated, and the transfer function between each acoustic source element and the receiver is obtained by interpolation of the results produced by modelling algorithm SCOOTER in Step 1). This interpolation involves both amplitude and phase of the transfer function;

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

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

5) The overall signal waveform is squared and integrated to obtain the received SEL.

#### 3.2.1.2 Modelling scenarios

One source location at the southeast corner of the Operational Area was selected for the short range modelling. The modelling location was selected as it has the shallowest water depth of the Operational Area which is the location where there is the potential for the largest SEL's and its details are provided in **Table 3**.

The worst case modelling conditions for underwater noise propagation applicable to the proposed survey have been assumed for the short range modelling, i.e. for location S1 the fine sand seabed sediment and spring sound speed profiles.

**Table 3 Details of the selected source location for the short range modelling. The coordinate system is based on Map Projection WGS 84 / Mercator 41.**

| Source Location | Water Depth, m | Coordinates [Easting, Northing] | Locality |
|---|---|---|---|
| **S1** | 114 | [6207755, -3536791] | Southeast corner of the 'Nikau 3D' Operational Area within North Taranaki Basin, with close proximity to the adjacent marine mammal sanctuary |

### 3.2.2 Long range modelling

#### 3.2.2.1 Modelling methodology and procedure

The long range modelling case can achieve reasonable accuracy of prediction considering that it generally involves complex and variable environmental factors such as sound speed profiles and bathymetric variations. Therefore, the modelling prediction for the long range case is carried out using the far-field source levels of octave frequency bands and their corresponding transmission loss calculations.

The fluid parabolic equation (PE) modelling algorithm RAMGeo (Collins, 1993) is used to calculate the transmission loss between the source and the receiver. RAMGeo is an efficient and reliable PE algorithm for solving range-dependent acoustic problems with fluid seabed 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 obtained 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.

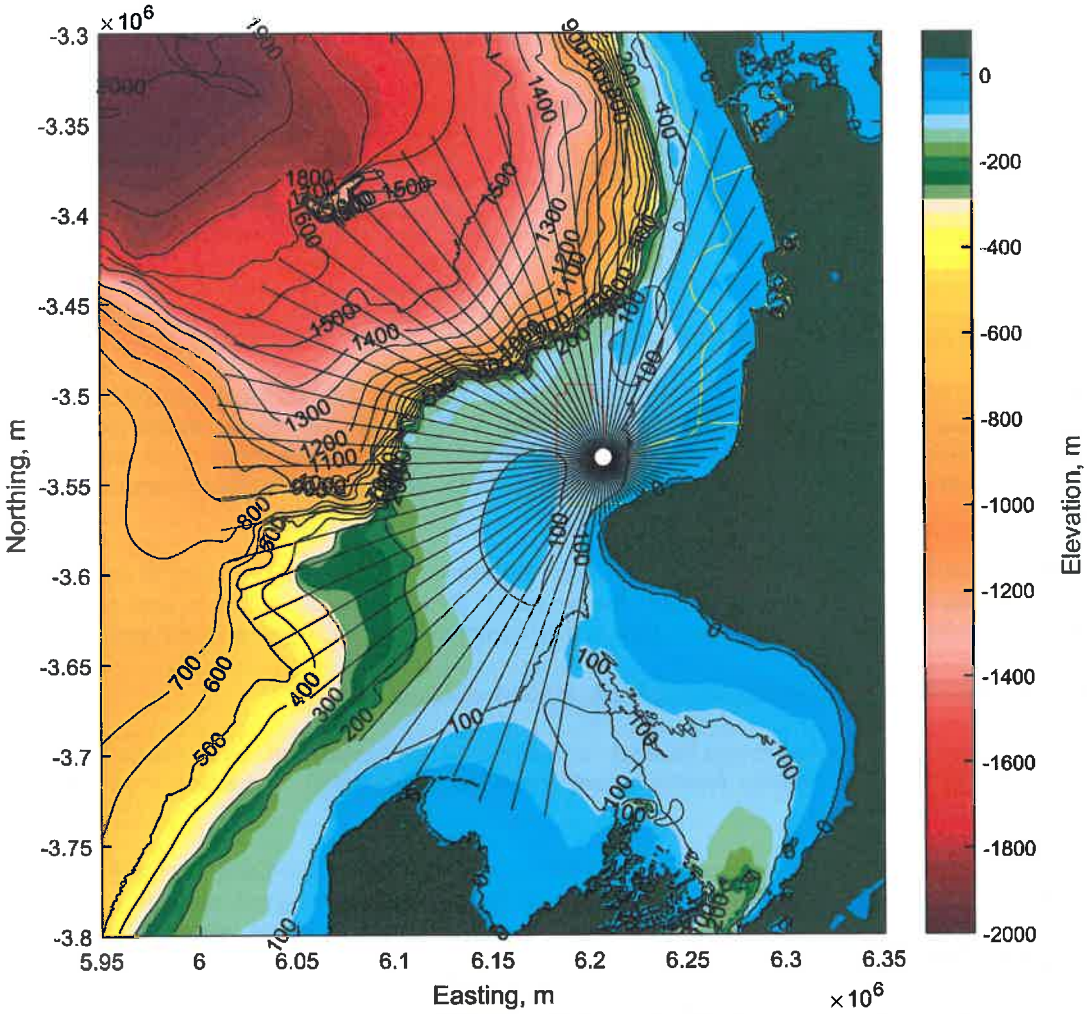
#### 3.2.2.2 Modelling scenarios

The same source location as for the short-range modelling (S1) was selected for the long-range modelling scenario.

The spring seasonal 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.

OMV has advised that the acquisition will be carried out with the acoustic source array in a North-South orientation.

**Figure 11** **Long range modelling source location (white dot), with modelling sound propagation paths (black lines) overlaying local bathymetry. The coordinate system is based on Map Projection WGS 84 / Mercator 41.**



# 4 RESULTS

### 4.1.1 Short range modelling

The received SEL levels from the Bolt 1900 LLXT 3260 cubic inch array for the source modelling location (S1) with the spring season sound speed profile and the corresponding seabed sediment have been calculated. The maximum received SELs across the water column for the modelling source location are presented as a function of azimuth and range from the centre of the array in **Figure 12**. The figure illustrates higher SELs in both the in-line and cross-line directions as a result of the directivity of the source array.

The scatter plot of the predicted maximum SELs across the water column from the source array for all azimuths are displayed in **Figure 13**, as a function of range from the centre of the source array, together with the mitigation threshold levels (i.e. 186 dB and 171dB re 1µPa$^2$·S) and mitigation ranges (i.e. 200 m, 1.0 km and 1.5 km).

The maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa$^2$·s at 200 m and below 171 dB re 1µPa$^2$·s at 1.5 km. However, the modelling results have shown that the maximum SELs are above 171 dB re 1µPa$^2$·s at 1.0 km, predominantly around the cross-line directions due to its extremely strong directivities.

The predictions of the maximum SELs received at the three mitigation ranges are listed in **Table 4**.

Table 5 presents the ranges from the centre of the source array to where the predicted maximum SELs meet the threshold levels (186 dB and 171 dB re 1µPa$^2$·s).

**Table 4 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the Bolt 1900 LLXT 3260 cubic inch array.**

| **Source location** | **Water depth, m** | **Seafloor** | **SEL at different ranges, dB re 1µPa$^2$·s** | | |
|---|---|---|---|---|---|
| | | | **200 m** | **1.0 km** | **1.5 km** |
| **S1** | 114 | Fine sand | 183.2 | 173.2 | 170.3 |

**Table 5 Ranges from the center of the Bolt 1900 LLXT 3260 cubic inch array where the predicted maximum SELs for all azimuths equal the SEL threshold levels.**

| **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** | 114 | Fine sand | 136 m | 1,340 m |

**Figure 12** The predicted maximum received SELs across the water column from the Bolt 1900 LLXT 3260 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. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

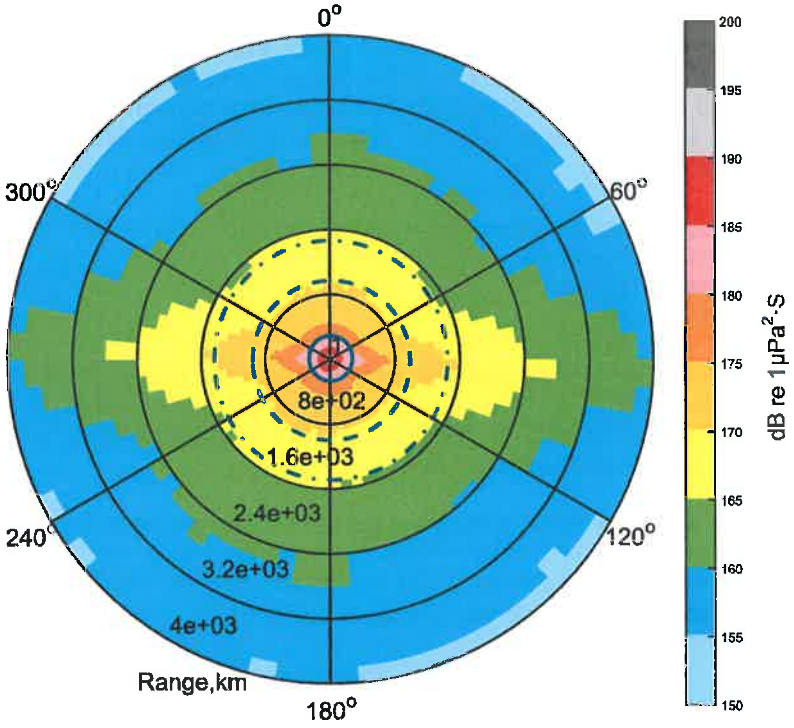
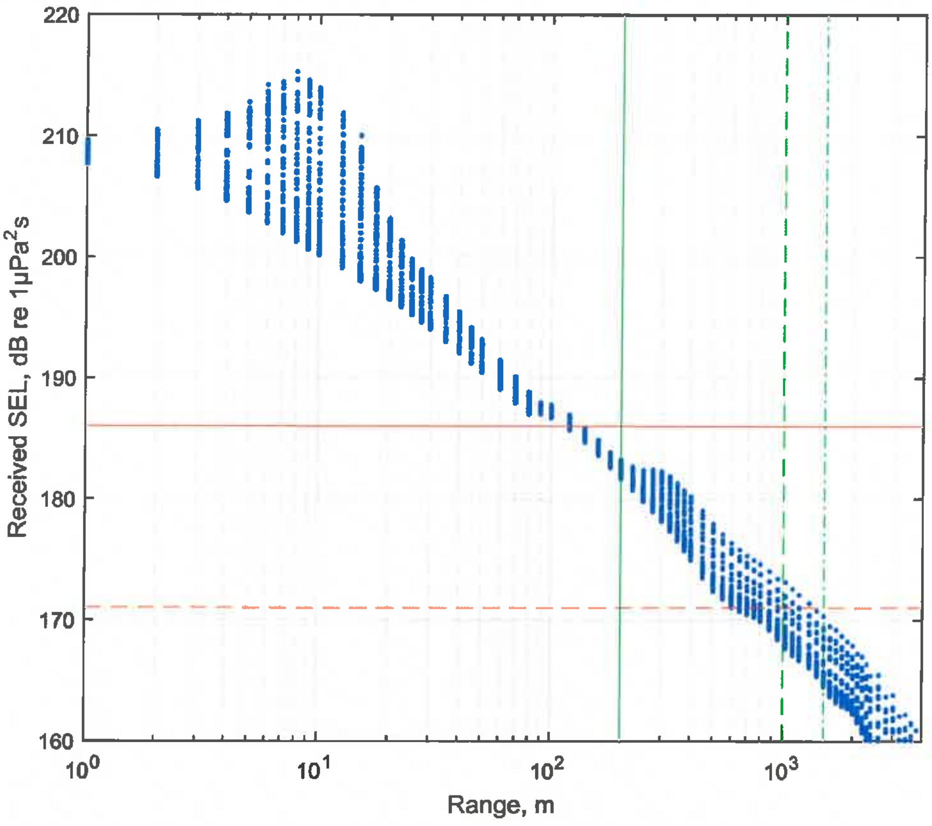


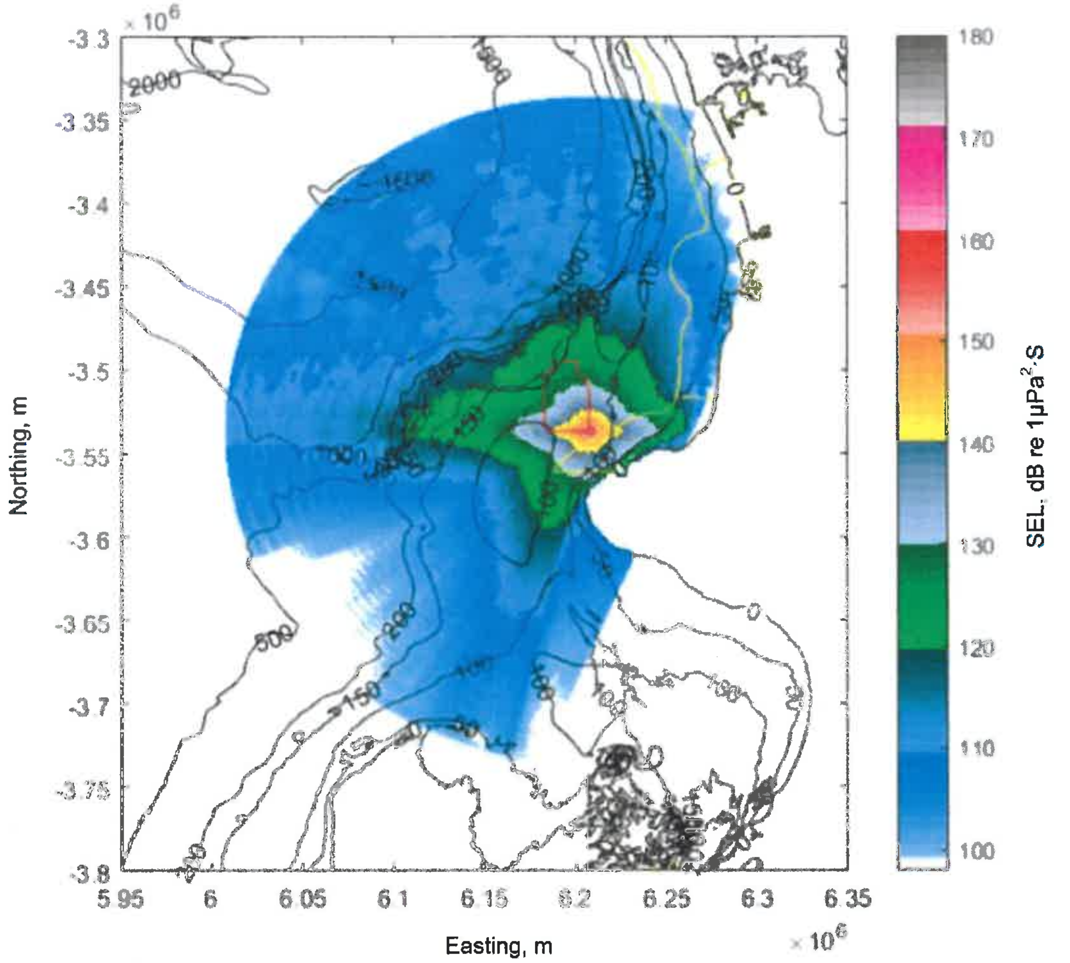
**Figure 13** **Scatter plots of predicted maximum SELs across the water column from the Bolt 1900 LLXT 3260 cubic inch array for all azimuths as a function of range from the center of the source array. Horizontal red lines show mitigation thresholds of 186 dB re 1µPa2·S (solid) and 171dB re 1µPa2·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).**



### 4.1.2 Long range modelling

**Figure 14** shows the contour image of the predicted maximum SELs received at locations up to 200 km from the long range source location (S1), overlaying the local bathymetry contours.

**Figure 14 Modelled maximum SEL (maximum level at any depth) contour (for the source location to a maximum range of 200 km), overlaying with bathymetry contour lines.**



As can be seen from **Figure 14**, the received noise levels at far-field locations vary significantly at different angles and distances from the source. This directivity of received levels is due to a combination of the directivity of the source array, and propagation effects caused by bathymetry and sound speed profile variations.

**Figure 15** and **Figure 16** present the modelled SELs vs range and depth along the in-line North-South and South-North direction respectively.

Higher noise attenuations are predicted for the propagation path along the shallow water area in the south and southeast directions than that in the northern 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 and western directions.

**Figure 17** and **Figure 18** present the modelled SELs vs range and depth along the cross-line West-East and East-West direction respectively.

High noise attenuation is predicted for the propagation over the path sections with up-slope bathymetry profiles within the shallow water region in the eastern direction. The maximum SELs received from the source location S1 in the western direction at a distance of 200 km are predicted to be as high as 112 dB re 1μPa$^2$·S, which is the highest received SEL at 200 km among all azimuths.

The nearest boundary of the West Coast North Island Marine Mammal Sanctuary is approximately 5.5 km from the Operational Area. The maximum SELs received from the source location S1 at the nearest boundary point are predicted to be approximately 150 dB re 1μPa$^2$·S. The majority of the marine sanctuary areas within a 50 km distance from the source location between the south and the east direction have predicted received noise levels to be above 120 dB re 1μPa$^2$·S. For other marine sanctuary areas further than 50 km, the received noise levels are predicted to drop from 120 dB re 1μPa$^2$·S at the east-northeast direction to values below 100 dB re 1μPa$^2$·S near the coastline within 200 km distance at the north-northeast direction.

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

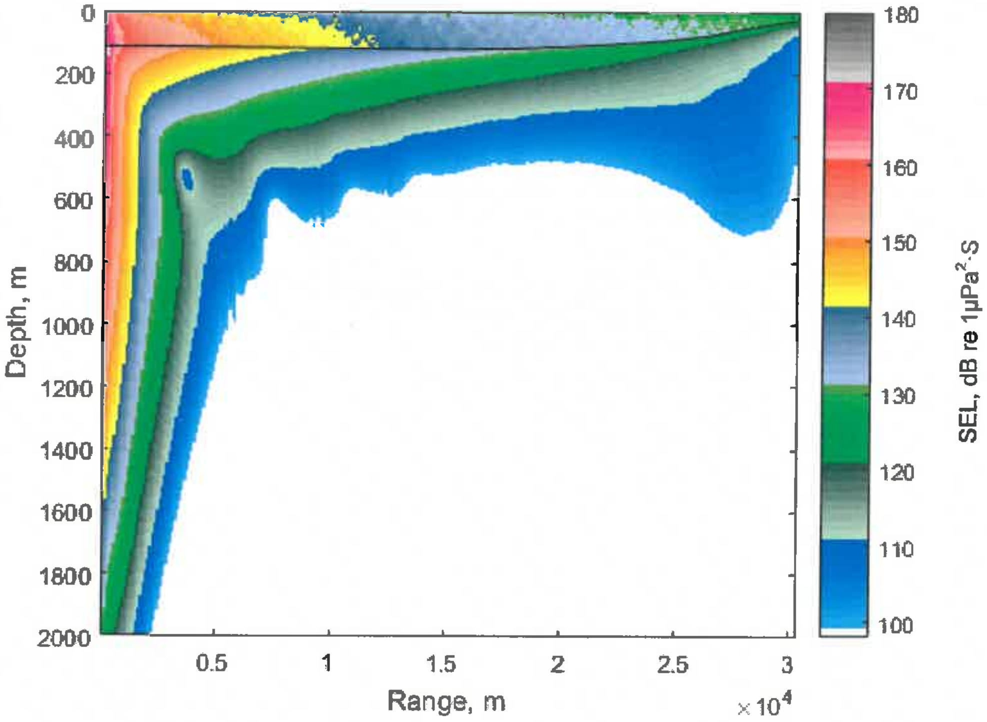


**Figure 16** **Modelled SELs vs range and depth along the propagation path in South-North in-line direction from the source location. Black line shows the seabed depth variation.**

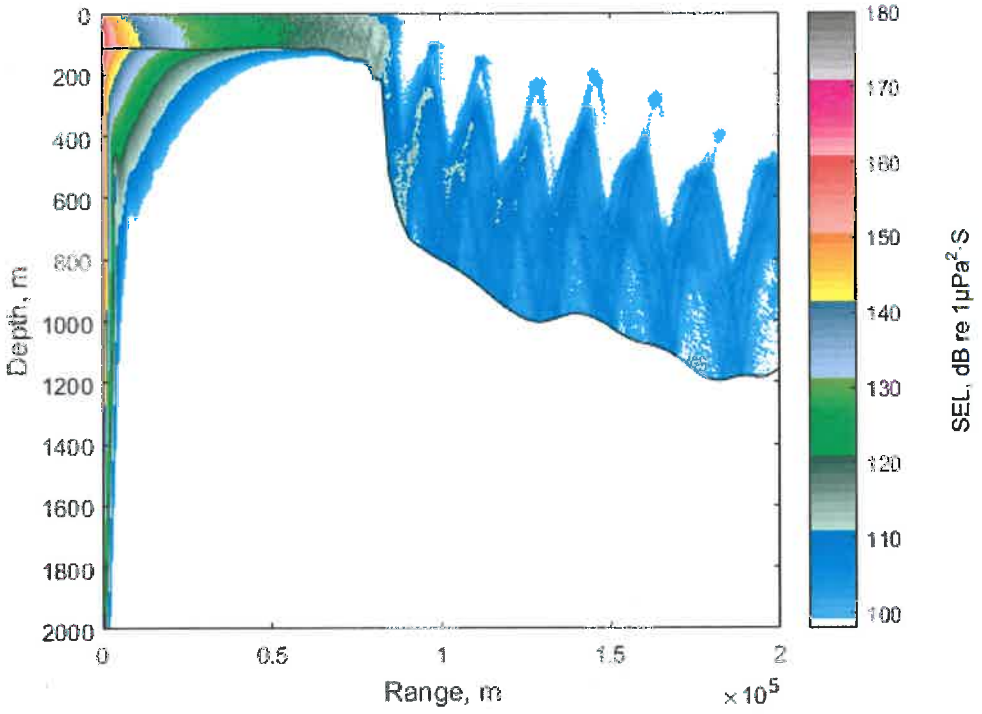


**Figure 17** **Modelled SELs vs range and depth along the propagation path in West-East cross-line direction from the source location. Black line shows the seabed depth variation.**

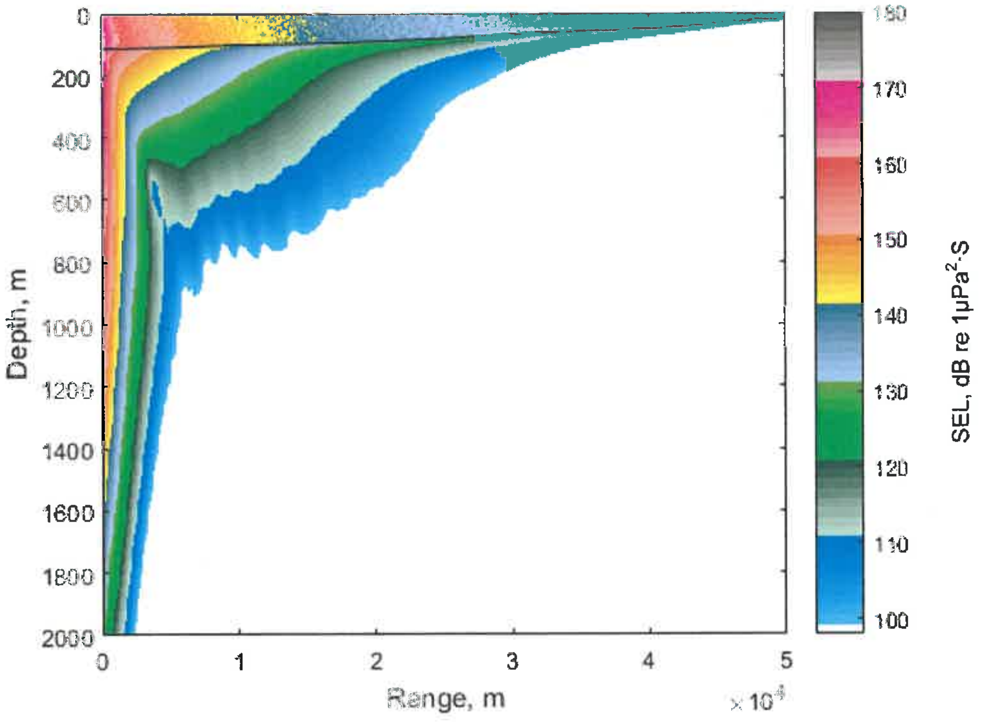
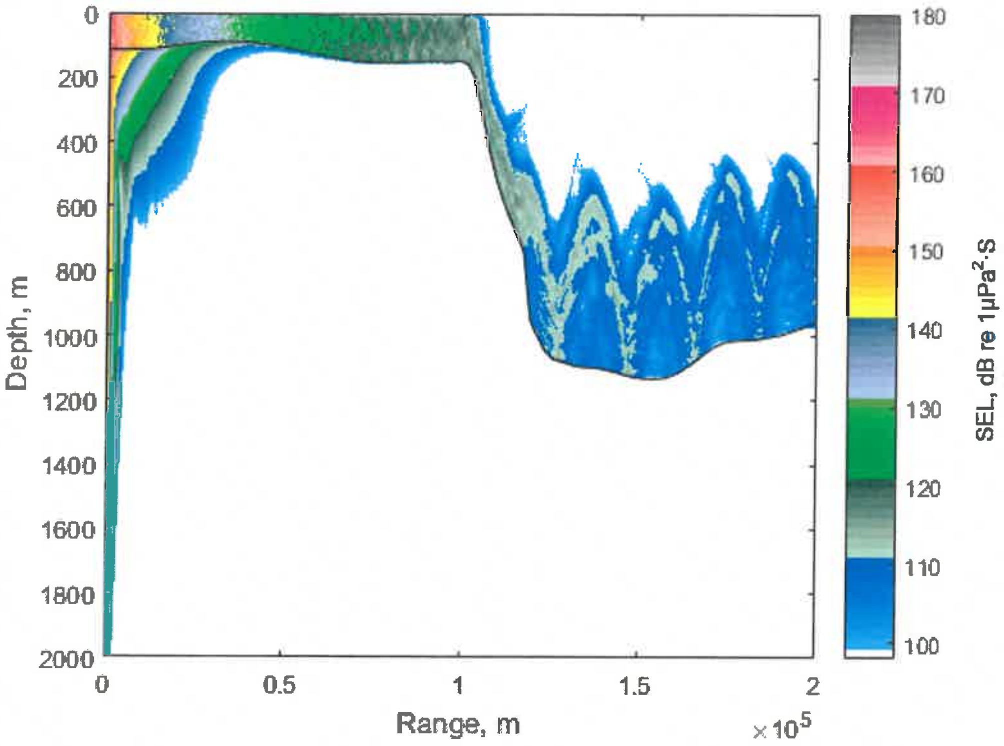


**Figure 18** Modelled SELs vs range and depth along the propagation path in East-West cross-line direction from the source location. Black line shows the seabed depth variation.



# 5 CONCLUSIONS

OMV is planning to acquire a 3D marine seismic survey of approximately 1015 km$^2$ within the North Taranaki Basin (i.e. the 'Nikau 3D Seismic Survey') within the spring season.

The short range modelling prediction using worst case modelling conditions (i.e. spring sound speed profile and fine sand seabed half-space) demonstrates that the maximum received SELs over all azimuths are predicted to be below 186 dB re 1µPa$^2$·s at 200 m and below 171 dB re 1µPa$^2$·s at 1.5 km for the selected source location with a water depth of 114 m. However, the modelling results have shown that the maximum SELs are above 171 dB re 1µPa$^2$·s at 1.0 km, predominantly around the cross-line directions due to its extremely strong directivities.

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 West Coast North Island Marine Mammal Sanctuary has a minimum distance of approximately 5.5 km to the operational area. The maximum SELs received from the chosen source location with the closest distance to the sanctuary are predicted to be approximately 150 dB re 1µPa$^2$·S. The majority of the marine sanctuary areas within a 50 km distance from the source location between the south and the east direction have predicted received noise levels to be above 120 dB re 1µPa$^2$·S. For other marine sanctuary areas further than 50 km, the received noise levels are predicted to drop from 120 dB re 1µPa$^2$·S at the east-northeast direction to values below 100 dB re 1µPa$^2$·S near the coastline within 200 km distance at the north-northeast direction.

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## 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 $P_{ref} = 1\ \mu\text{Pa}$ |
| *Root-Mean-Square Sound Pressure Level (RMS SPL)* | The mean-square sound pressure is the average of the squared pressure over some duration. The root-mean-square sound pressure level is the level of the root of the mean-square pressure against the reference pressure |
| *Sound Exposure Level (SEL)* | SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period |
| *Power Spectral Density (PSD)* | PSD describes how the power of a signal is distributed with frequency. |
| *Source Level (SL)* | The acoustic source level is the level referenced to a distance of 1m from a point source |
| *1/3 Octave Band Levels* | The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide. |
| *Sound Speed Profile* | A graph of the speed of sound in the water column as a function of depth |

# Appendix D

Report Number 740.10013.00330

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# MARINE MAMMAL MITIGATION PLAN

# Marine Mammal Mitigation Plan:

## OMV New Zealand Limited – Nīkau 3D Seismic Survey, Taranaki Basin, New Zealand – 2016

BPM-OMV-Nīkau 3D SS-MMMP-v1.3
25/10/2016

Blue Planet Marine

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Last updated: 25 October 2016

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# 1. Introduction

This document has been developed by Blue Planet Marine (BPM) for OMV New Zealand Limited (OMV) in order to meet the requirements for a Marine Mammal Mitigation Plan (MMMP) for the Nīkau 3D Seismic Survey (the survey).

This MMMP outlines the procedures to be followed by observers and crew in order to guide survey operations. It should be read in conjunction with the *2013 Code of Conduct for Minimising Disturbance to Marine Mammals from Seismic Survey Operations* (the Code) and the OMV MMIA developed by SLR Consulting NZ Limited (SLR) specifically for this survey. The Code is the primary tool for describing mitigation and reporting required for seismic surveys consistent with NZ legislation. It should be the primary reference for Marine Mammal Observers (MMOs) and PAM operators (PAMOs) during a survey. This MMMP is specific to the survey and provides additional and supplemental information useful in the completion of MMO and PAM roles.

# 2. The OMV New Zealand Limited – Nīkau 3D Seismic Survey, Taranaki Basin, New Zealand – 2016

Information provided in the MMIA for the survey has been used by BPM in the development of this MMMP. SLR was engaged by OMV to prepare a MMIA for an approximate 1,015 km$^2$ survey in the Taranaki Basin, scheduled to commence in November 2016. The survey area will be located within PEP 57075 and PEP 60092, and will be bound by an Operational Area allowing for line turns, acoustic source testing and soft start initiation (Figure 1).

The primary objective of the survey is to assess hydrocarbon prospectivity within the area. It is anticipated that the survey will take up to 30 days to complete, depending on weather constraints and marine mammal encounters. Operations will be conducted 24 hours per day, 7 days per week; also subject to suitable weather conditions and marine mammal encounters.

## 2.1 Seismic vessel and acoustic source

The survey will use the seismic vessel *PGS Apollo* and will tow up to 10 solid streamers, approximately 8 km in length and 150 m apart. The acoustic source will have an effective volume of 3,260 in$^3$ and will be comprised of three sub-arrays, each with eleven acoustic sources. The acoustic array will be located at a depth of 7 m below the sea surface.

The acoustic source will have an operating pressure of 2,000 psi and will be fired at a sourcepoint interval of 16.67 m apart. For a typical boat speed of 4.5 knots (kts), this equates to a sourcepoint activation every 7.2 seconds. Given the volume of the acoustic source being used, the survey is classified as a **Level 1** survey under the Code. The mitigation procedures set out in this MMMP will adhere to the requirements of a Level 1 survey as stipulated in the Code and any additional mitigation measures determined via the MMIA process and outlined in Section 5 of this document.

Two smaller support/chase vessels will be in close proximity to the *PGS Apollo* for the duration of the survey, except when required to go into port.

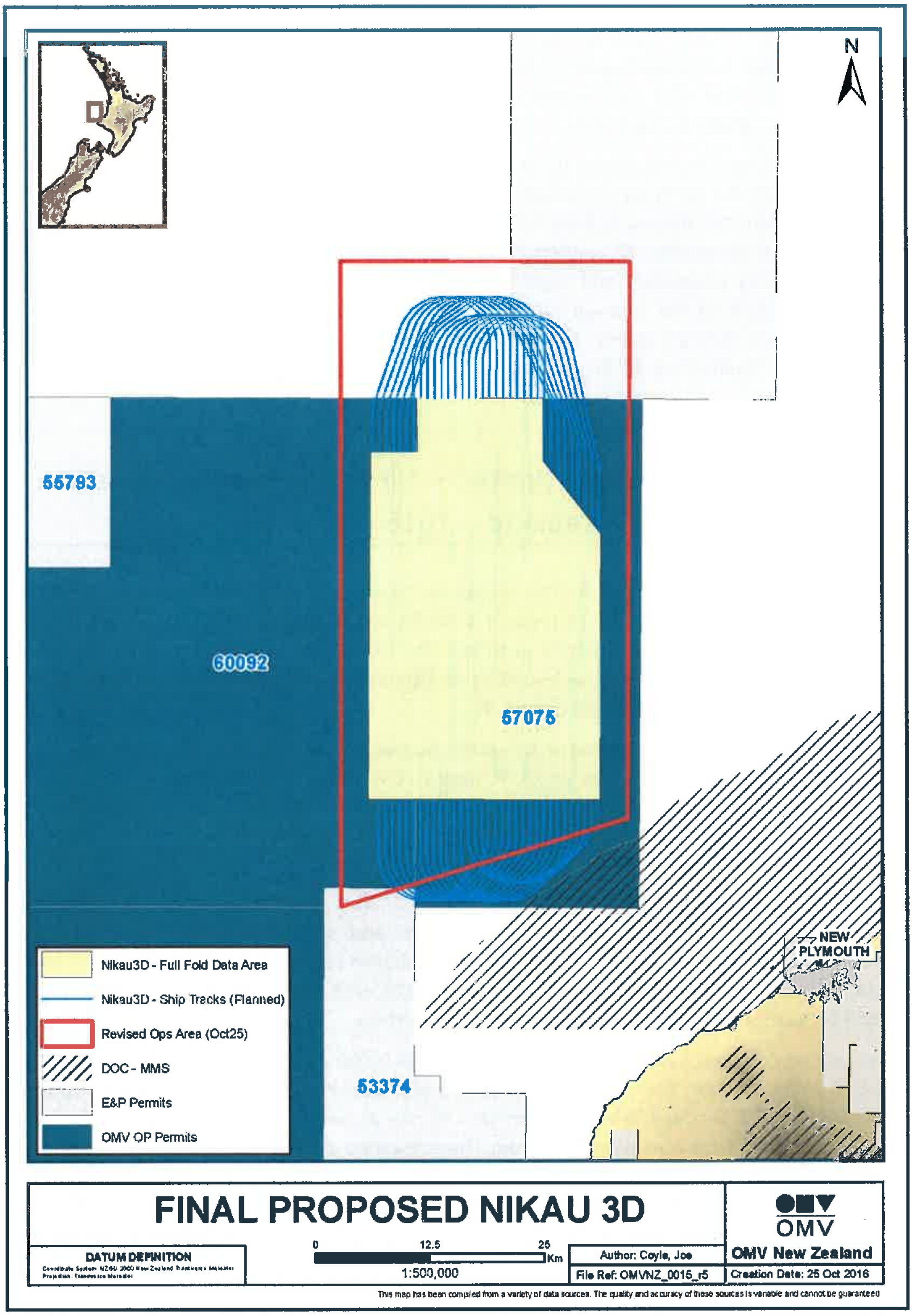

Figure 1: Location of the OMV Nīkau 3D Seismic Survey.

(Observers to refer to the VADAR system for the coordinates of the Operational Area.)

## 2.2 Operational Area

The Operational Area for the survey is beyond the 12-nautical mile Territorial Sea boundary, but within the New Zealand Exclusive Economic Zone (Figure 1). Amongst other legislation, the survey is required to comply with the Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects – Permitted Activities) Act and the Code.

When a seismic survey is proposed within Areas of Ecological Importance (AEI), the Code requires Sound Transmission Loss Modelling (STLM) to be undertaken in order to validate the standard mitigation zones specified in the Code. The Operational Area for this survey is located beyond AEI and although STLM is not required, OMV undertook this modelling.

OMV's STLM was based upon the specific configuration of the acoustic array deployed from the *PGS Apollo* and the environmental conditions within the Operational Area. The STLM predicted that the 1.0 km mitigation zone described in the Code would not be adequate for the protection of marine mammals and that Sound Exposure Levels (SEL) would be equal to or above the behaviour criteria threshold specified for mitigation in the Code. Due to this OMV has adopted a larger mitigation zone for Species of Concern (SOC): detection of SOC with or without calves within 1.5 km of the source will result in a delay or shutdown of the source as appropriate.

There is one Marine Mammal Sanctuary (MMS) in the vicinity of the survey. At its closest point, the West Coast North Island MMS is located approximately 5.5 km to the southeast corner of the Operational Area. The MMS was established in 2008 to protect Māui dolphins from fishing and other anthropogenic pressures. Māui dolphins are thought to occur in very low densities in Taranaki waters and may be present within the Operational Area.

The Tapuae Marine Reserve, Parininihi Marine Reserve and the Ngā Motu/Sugar Loaf Islands Marine Protected Area are all located within the boundaries of the West Coast North Island MMS.

# 3. Record Keeping and Reporting

The observers (MMOs and PAMOs) are responsible for maintaining records of all marine mammal sightings/detections and mitigation measures taken throughout the survey. Observers are also required to monitor and record seismic operations, the power output of the acoustic source while in operation, observer effort and sighting conditions. These and other reporting requirements are detailed in Appendix 2 of the Code. Sections 4.2.4 and 4.2.5 of the MMIA present a summary of the most commonly occurring or protected marine mammal species known to occur in the Operational Area.

Observers are to accurately determine distances/bearings and plot positions of marine mammals whenever possible throughout the duration of sightings. Positions of marine mammals should be plotted in relation to the vessel throughout a detection. GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards, or any other appropriate tools should be used to accurately determine distances/bearings and plot positions of marine mammals.

The operator will ensure that information relating to the activation of an acoustic source and the power output levels employed throughout survey operations is readily available (e.g. in a place of convenience for the qualified observers while conducting their normal duties) to support the activities of the qualified observers in real time by providing a display screen for acoustic source operations.

Please review Appendix 2 of the Code carefully. Note that you are required to record the power levels (and timing) of at least one random soft start per swing[1].

Note: the Code is mandatory within the NZ EEZ, as such record keeping should be of a high standard as it may form the basis of compliance or enforcement action by the authorities.

All data must be recorded in a standardised Department of Conservation (DOC) Reporting Form. Datasheets are available from www.doc.govt.nz/notifications and are in Excel format. With regard to these forms please note the following advice from DOC:

- Always save the forms in MS Excel 2003 version, with macros enabled;
- Do not attempt to use the forms on a Macintosh device; and
- Do not cut/paste within the document (copy/paste should be okay, but cutting and pasting causes problems with formulas and validation).

It is recommended that observers test the functionality of the datasheets prior to mobilisation and refamiliarise themselves with their use. In particular, note that macros must be enabled.

All raw datasheets shall be submitted by the qualified observer directly to the Director-General of DOC (refer Appendix 5 of the Code for postal and email addresses) within 14 days of a completed MMO/PAMO rotation or at the completion of the survey. Prior to submission to DOC, these data sheets are to be reviewed by the BPM Project Manager so please ensure that sufficient time is made for such review.

A written report will be submitted to the Director-General of DOC at the earliest opportunity, but no longer than 60 days after completion of survey.

There are a number of situations that require immediate notification to DOC. These are listed in Table 1, in Section 6. Where uncertainty or ambiguity in application/interpretation of the Code arises, clarity can be sought from the Director-General of DOC.

In addition to the recording and reporting requirements set out in the Code, OMV has committed to the following mitigation measures for this survey:

- A larger than standard mitigation zone of 1.5 km will be in place for Species of Concern (with or without calves).
- A MMO will be on watch and recording marine mammal sightings during transit to and from the Operational Area during daylight hours and in good sighting conditions.
- MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea to DOC using the Taranaki DOC office (Callum Lilley) as contact on 06-759 0350.
- MMOs and PAMOs will notify DOC immediately of any southern right whale, humpback whale or Hector’s/Māui dolphin sightings/detections.
- Weekly MMO reports to be provided to DOC and EPA.

## 3.1 Validation of Sound Transmission Loss Modelling (STLM)

As outlined in Section 2, OMV have undertaken STLM. OMV will ground-truth its results during the survey. Representative data recorded on the seismic streamers during the seismic survey will be used to compare actual water column sound exposure levels with pre-survey modelled predictions.

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[1] Note: Text in blue boxes are recommendations or further explanations to observers from BPM and/or DOC.

These results will be verified to ensure the mitigation zones are appropriate. The validation results and report will be provided by OMV to Dave Lundquist (dlundquist@doc.govt.nz) at DOC.

It is recommended that the MMO Team Leader undertake early communications with the relevant personnel in order to be aware of the timing of the ground-truthing exercise.

Refer to Section 5.1.2.1 and Appendix C of the MMIA for details of the STLM.

## 3.2 Contact details for the Department of Conservation

During the survey, the first point of contact within DOC is Dave Lundquist (dlundquist@doc.govt.nz or . If a response is required urgently then telephone communications are recommended but in all other circumstances email correspondence should suffice. Should Dave Lundquist be unavailable, then Ian Angus (iangus@doc.govt.nz or ) is DOC's backup contact. If neither are available, please phone 0800DOCHOT (0800-362-468) and state the following:

1) You wish to provide information to the Marine Species and Threats Team, National Office;
2) The name of the MMO/PAMO, the seismic survey and boat you are currently on;
3) The time and date;
4) The issue/enquiry they wish to pass on to Ian Angus; and
5) Where you can be contacted with a reply (if appropriate).

### 3.2.1 Communication protocol

The communication protocol to be followed for reporting to DOC is as follows:

For **general reporting of non-urgent issues** to DOC the communication protocol is:

- MMO Team Leader to contact BPM Project Manager ashore (Simon Childerhouse);
- BPM to contact OMV (Michael Lord or Matiu Park); and
- OMV to contact DOC (Dave Lundquist or other).

For **urgent communications**, any qualified MMO can contact DOC directly either by email or by phone under the following conditions:

- Qualified MMO undertaking direct communication with DOC must inform the MMO Team Leader, Party Chief (or nominated OMV person) and the Client Reps of the issue and intention to contact DOC, and keep these people informed of discussions and associated events;
- The BPM Project Manager and onshore OMV Project Manager (Michael Lord) must be kept informed;
- If the contact is by email, then the Team Leader should consider making a phone call advising DOC of the situation; and
- All direct contacts to DOC via phone must be followed up by an email to DOC and OMV at the earliest opportunity to provide written confirmation of the message.

## 4. Mitigation Measures Required Under the Code

The survey is classified as a Level 1 survey under the Code. Within the Operational Area, the marine mammal impact mitigation measures required can be divided into three principal components:

1) The use of dedicated observers (i.e. MMOs and PAMOs);
2) The mitigation measures to be applied; and
3) The mitigation actions to be implemented, should a marine mammal be detected.

### 4.1 Dedicated observers (MMOs and PAMOs)

As this is a Level 1 survey, there will be two MMOs and two PAMOs on board the seismic survey vessel for the duration of the survey. The training and experience of the observers will meet the requirements stipulated in Section 3.4 of the Code. **There will be at least one MMO (during daylight hours) and one PAMO on watch at all times while the acoustic source is in the water in the Operational Area.** In addition, a trainee iwi MMO will be on board and will be mentored by the other MMOs.

If the acoustic source is in the water but inactive, such as while waiting for bad weather conditions to pass, the qualified observers have the discretion to stand down from active observational duties and resume at an appropriate time prior to recommencing seismic operations. This strictly limited exception must only be used for necessary meal or refreshment breaks or to attend to other duties directly tied to their observer role on board the vessel, such as adjusting or maintaining PAM or other equipment, or to attend mandatory safety drills.

It is recommended that:

- MMOs conduct daylight observations from half an hour before sunrise to half an hour after sunset;
- Fatigue and effective watch-keeping be managed by limiting watches to a maximum of 4 hours; and
- The maximum on-duty shift duration must not exceed 12 hours in any 24-hour period.

The primary role of the observers is to detect and identify marine mammals and guide the crew through any mitigation procedures that may be required. **Any qualified observer on duty has the authority to delay the start of operations or shut down an active survey according to the provisions of the Code and MMIA.** In order to work effectively, clear lines of communication are required and all personnel must understand their roles and responsibilities with respect to mitigation.

It is recommended that:

- Where possible, two MMOs are on watch during pre-start observations and soft starts;
- Before departure or while in transit to the Operational Area the observers and OMV representative deliver a presentation to all relevant crew members detailing observer roles and mitigation requirements;
- The observers and OMV representative hold briefings with key personnel prior to the commencement of seismic operations; and

- The observers provide posters detailing mitigation procedures and communications protocols and display these in the *PGS Apollo* instrument room, at the PAM station and on the Bridge as well as in the Bridge of associated seismic survey support vessels (refer Addenda 1, and Addenda 2).

Undertaking work-related tasks, such as completing reporting requirements, while monitoring equipment is allowed during duty watch, but PAMOs must not be distracted by non-work activities such as listening to music or watching TV/DVDs etc.

### 4.1.1 Safety drills

Attendance by MMO and PAMOs at a safety drill at least once during each rotation is typically mandatory (e.g. the vessel HSE plan will specify the number). Although not specified in the Code, safety of personnel at sea takes priority over marine mammal mitigation requirements. Safety drills may be conducted when the acoustic source is active. In this case, endeavours should be made to arrange rosters such that observers attend alternate drills, thus enabling mitigation to be maintained. In all cases, observers must comply with the mandatory safety code of the vessel and any other relevant maritime or Health and Safety requirements.

### 4.1.2 PAM not operational

Section 4.1.2 of the Code states: "*At all times while the acoustic source is in the water, at least one qualified MMO (during daylight hours) and at least one qualified PAM operator will maintain watches for marine mammals*".

The Code defines PAM as "*calibrated hydrophone arrays with full system redundancy*". BPM has provided full redundancy for this survey by providing two full sets of PAM equipment plus an additional backup PAM hydrophone cable. However, there may be occasions where PAM is not operational.

The Code was first implemented in 2012. In 2013 it was updated. One update relates to times when PAM is not operational. Section 4.1.2 of the Code states that:

*"If the PAM system has malfunctioned or become damaged, operations may continue for 20 minutes without PAM while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM gear must be repaired to solve the problem, operations may continue for an additional 2 hours without PAM monitoring as long as all of the following conditions are met:*

- *It is daylight hours and the sea state is less than or equal to Beaufort 4*
- *No marine mammals were detected solely by PAM in the relevant mitigation zones in the previous 2 hours*
- *Two MMOs maintain watch at all times during operations when PAM is not operational*
- *DOC is notified via email as soon as practicable with the time and location in which operations began without an active PAM system*
- *Operations with an active source, but without an active PAM system, do not exceed a cumulative total of 4 hours in any 24 hour period."*

MMOs and PAMOs should familiarise themselves with this revision to the Code, including the conditions set out above. For clarity, the period that a survey may operate without PAM is a maximum of 2 hours 20 minutes and only when the conditions identified in Section 4.1.2 of the 2013 Code are satisfied. **Once this time is exceeded, the source must be shut down until PAM is operational again.**

## 4.2 Crew observations

Section 3.8.6 of the Code requires the following in relation to crew observations:

*"If a crew member on board any vessel involved in survey operations (including chase or support vessels) observes what may be a marine mammal, he or she will promptly report the sighting to the qualified MMO, and the MMO will try to identify what was seen and determine their distance from the acoustic source.*

*In the event that the MMO is not able to view the animal, they will provide a sighting form to the crew member and instruct on how to complete the form. Vessel crew can relay either the form or basic information to the MMO. If the sighting was within the mitigation zones, it is at the discretion of the MMO whether to initiate mitigation action based on the information available. Sightings made by members of the crew will be differentiated from those made by MMOs."*

## 4.3 Mitigation procedures

The proponent will observe the following mitigation practices:

### 4.3.1 Operational Area

Under the Code, an Operational Area must be designated outside of which the acoustic source will not be activated. This includes testing of the acoustic source and soft starts. The Operational Area is defined by the coordinates provided in Addenda 3. These have been loaded into VADAR for real time monitoring of vessel location and marine mammal detections relative to the Operational Area.

### 4.3.2 Operational capacity

The operational capacity of the acoustic source is set out in the MMIA and outlined in Section 2.1 of this MMMP. This operational capacity should not be exceeded during the survey, except where unavoidable for source testing and calibration purposes only[2]. All occasions where activated source volume exceeds notified operational capacity must be fully documented in observer reports. It is the responsibility of the operator to immediately notify the qualified observers if operational capacity of the acoustic source is exceeded at any stage[3].

### 4.3.3 Sighting conditions

**Good sighting conditions** means in daylight hours, during visibility of more than 1.5 km, and in a sea state of less than or equal to Beaufort 3.

**Poor sighting conditions** means either at night, or during daylight visibility of 1.5 km or less, or in a sea state of greater than or equal to Beaufort 4.

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[2] D Lundquist, DOC (25 March 2014): "Please note that if the operational capacity is exceeded at any other time (including soft starts), this is a non-compliance incident and should be reported as such."

[3] D Lundquist, DOC (25 March 2014): "qualified observer should be able to monitor this via a dedicated screen..."

### Beaufort 3

- Gentle breeze: 7–10 kts
- Wave height: 0.5–1 m
- Large wavelets. Crests begin to break; scattered whitecaps

**BEAUFORT FORCE 3**
*WIND SPEED:* 7-10 KNOTS

*SEA:* WAVE HEIGHT .6-1M (2-3FT). LARGE WAVELETS. CRESTS BEGIN TO BREAK, ANY FOAM HAS GLASSY APPEARANCE. SCATTERED WHITECAPS

### Beaufort 4

- Moderate breeze: 11-16 kts
- Wave height: 1–2 m
- Small waves with breaking crests. Fairly frequent whitecaps.

**BEAUFORT FORCE 4**
*WIND SPEED:* 11-16 KNOTS

*SEA:* WAVE HEIGHT 1-1.5M (3.5-5FT). SMALL WAVES BECOMING LONGER, FAIRLY FREQUENT WHITE HORSES

### 4.3.4 Transit

Though not required by the Code it is encouraged that a MMO be on watch while the seismic survey vessel is in transit to and from the Operational Area. If a marine mammal is sighted during transit, the sighting must be recorded in the standardised DOC Off Survey Reporting Form.

OMV has committed to a MMO being on watch and recording marine mammal sightings during daylight hours and good weather during transit to and from the Operational Area.

### 4.3.5 Outline of mitigation procedure

A diagram outlining the general components of the mitigation procedure is shown in Figure 2. Addenda 4 outlines a checklist to be completed by the MMO and/or PAMO on watch prior to the acoustic source being put into the water.

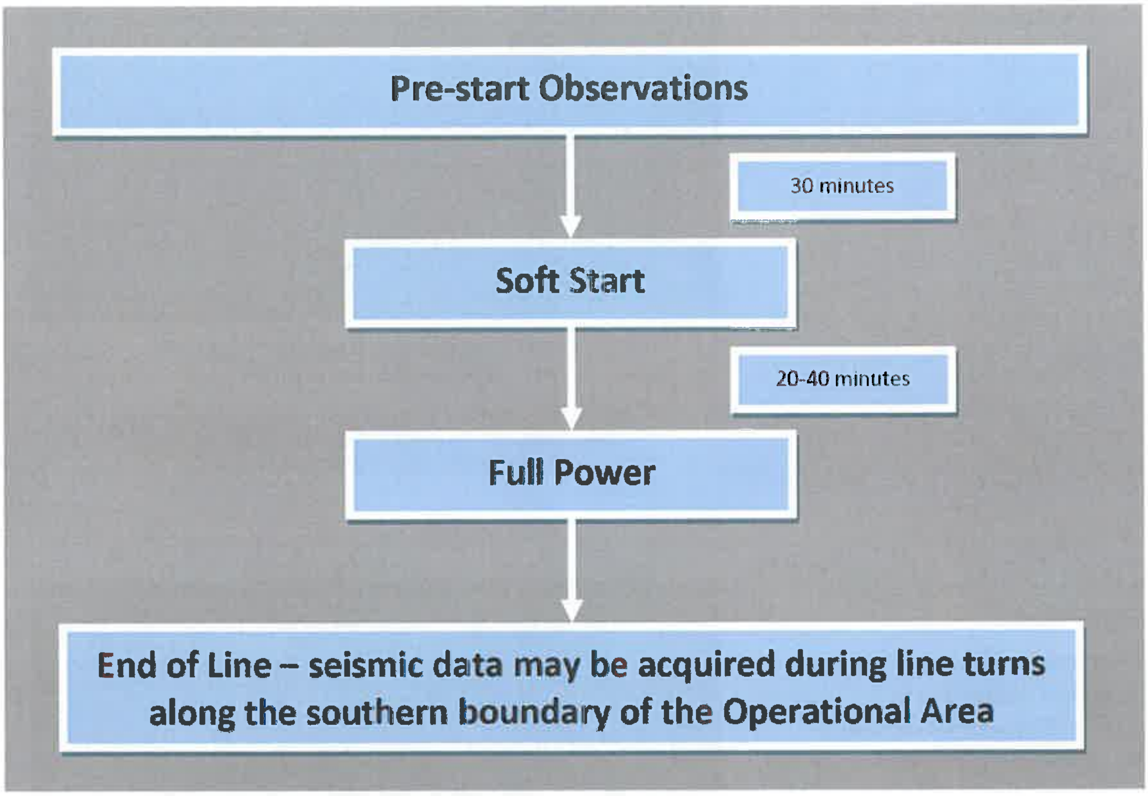

Figure 2: Seismic operations mitigation procedure.

### 4.3.6 Pre-start observations

A Level 1 acoustic source can only be activated if it is within the specified Operational Area, and no marine mammals have been observed or detected in the relevant mitigation zones as outlined in Section 4.5.

The source cannot be activated during daylight hours unless:

- At least one qualified MMO has continuously made visual observations all around the source for the presence of marine mammals, from the bridge (or preferably an even higher vantage point) using binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes; and
- Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAMO for at least 30 minutes before activation and no vocalising cetaceans have been detected in the relevant mitigation zones.

MMOs and PAMOs shall be notified at least 45 minutes prior to activation of the source to ensure that the 30 min of pre-start observations can be conducted.

The source cannot be activated during night-time hours or during poor sighting conditions unless:

- Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAMO for at least 30 minutes before activation, and
- The qualified observer has not detected vocalising cetaceans in the relevant mitigation zones.

Note: If a marine mammal is observed to move into a relevant mitigation zone during pre-start observations and then observed to move out again there is no requirement to delay soft start (providing that at least 30 minutes of pre-start observations have been completed). The important criterion is that **there are no marine mammals inside the relevant mitigation zones when the acoustic source is activated at the beginning of soft start and that at least 30 minutes of pre-start observations had been undertaken immediately prior**.

Another update to the Code in 2013 relates to commencement of operations in a new location in the survey programme for the first time (Section 4.1.3). When arriving at a new location for the first time, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless either:

- MMOs have undertaken observations within 20 nautical miles of the planned start up position for at least the last 2 hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than 2 hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if[4]:
    - PAM monitoring has been conducted for 2 hours immediately preceding proposed operations, and
    - Two MMOs have conducted visual monitoring in the 2 hours immediately preceding proposed operations[5], and
    - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 2 hours immediately preceding proposed operations, and
    - 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.

MMOs and PAMOs should familiarise themselves with this revision to the Code including the conditions.

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[4] D Lundquist, DOC (25 March 2014): "Please note that this option may only be used if there have not been two hours of good sighting conditions preceding operations. It cannot be used if there were 2 or more hours of good sighting conditions and marine mammals were sighted (i.e., the second option may only be used if weather conditions prevented the first condition being met, not if marine mammal presence prevented the first condition being met)"

[5] D Lundquist, DOC (3 November 2014): "... this requirement means that night time starts are not allowed, since visual observation cannot be undertaken immediately prior to start-up."

OMV will adhere to the requirements of Section 4.1.3. This includes when the seismic vessel leaves and returns to the Operational Area following a crew change or port call.

### 4.3.7 Soft starts

The soft start procedure shall be followed every time the source is activated. That is: the gradual increase of the source's power to the operational power requirement over a period of at least 20 minutes and no more than 40 minutes, starting with the lowest power acoustic source in the array. The operational source capacity (3,260 in$^3$) is not to be exceeded during the soft start period.

Soft starts will also be scheduled to minimise the interval between reaching full power and commencing data acquisition.

The only exception to the requirement to use the soft start procedure is when the acoustic source is being reactivated after a single break in firing of less than 10 minutes (not related to an observation of marine mammal), immediately following normal operations at full power (see Section 3.8.10 of the Code). However, it is not permissible to repeat the 10-minute break exception from soft start requirements by sporadic activation of acoustic sources at full or reduced power within that time.

Note: for each swing, at least one random sample of a soft-start should be recorded in the standard form and submitted to DOC for every rotation (see Appendix 2 of the Code).

### 4.3.8 Acoustic source testing

The Code requires that all testing of the acoustic source occurs within the Operational Area. Notified operational capacity should not be exceeded during the survey, except where unavoidable for source testing and calibration purposes only.

Seismic source tests are subject to soft start procedures (Section 4.3.7), though the 20-minute minimum duration does not apply. Where possible, power should be built up gradually to the required test level at a rate not exceeding that of a normal soft start. Acoustic source tests cannot be used for mitigation purposes, or to avoid implementation of soft start procedures.

### 4.3.9 Line turns

There will be no seismic acquisition during line turns, however, the acoustic source may be active if soft start procedures or acoustic source testing is in effect within the operational area.

## 4.4 Species of Concern

The full list of Species of Concern (SOC) as defined by the Code is shown in Addenda 5.

## 4.5 Mitigation zones

OMV will be implementing mitigation zones that differ from the standard ones outlined in the Code for Level 1 surveys. These will be applied during the survey and are outlined below:

1) 1.5 km from the centre of the acoustic source for SOC with or without calf; and
2) 200 m from the centre of the acoustic source for all other marine mammals.

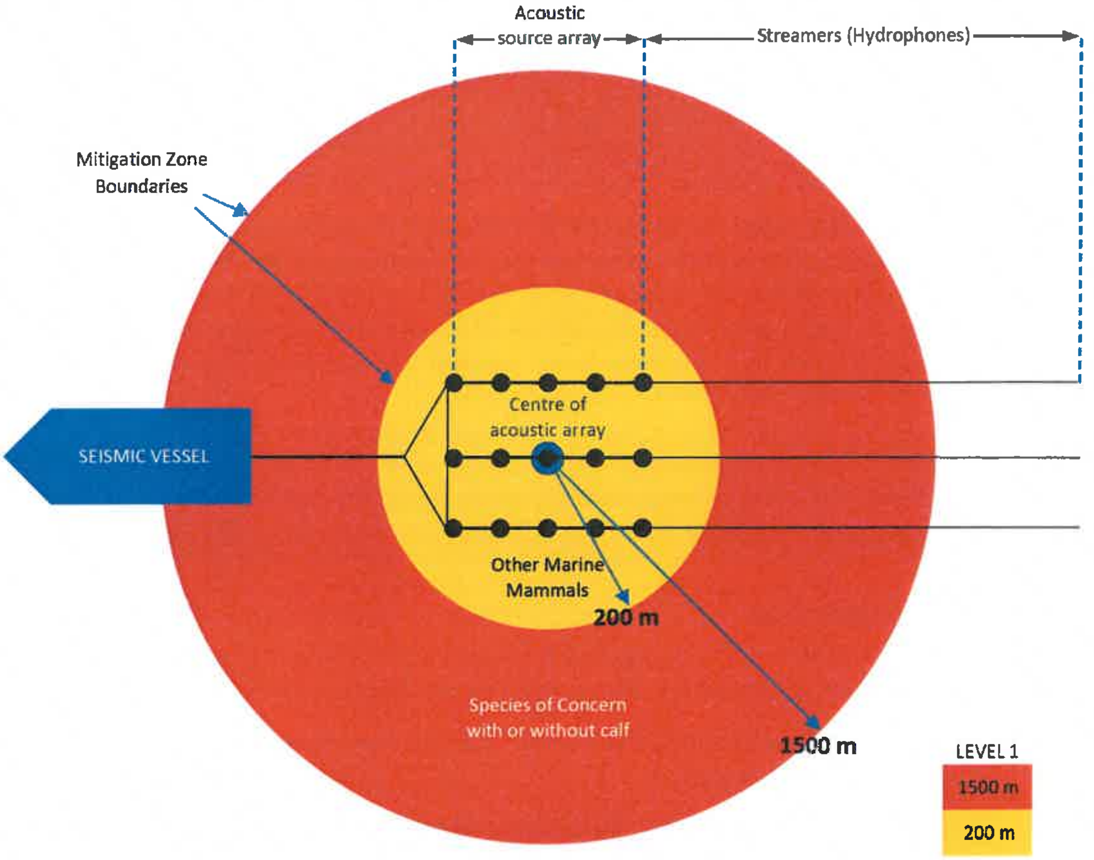

Figure 3: Mitigation Zone Boundaries for the survey.

### 4.5.1 PAM and calves

PAM cannot distinguish calves from adults, the Code therefore requires the proponent to apply the precautionary principle and the 1.5 km mitigation zone for any cetacean SOC detected by PAM.

PAMOs must be familiar with this requirement.

## 4.6 Mitigation actions

In the event that marine mammals are detected by the observer within the designated mitigation zones (1.5 km and 200 m), the observer will either delay the start of operations or shut down the source. These mitigation actions will apply to:

### 4.6.1 Species of Concern with or without calf

If during pre-start observations or when the acoustic source is active (including soft starts) the observer (MMO or PAMO) detects at least one cetacean SOC (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:

1) The observer confirms the group has moved to a point that is more than 1.5 km from the source; or
2) 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.

In regard to cetacean SOC with a calf: note that the requirements above apply to the entire group containing that calf. An explanatory note from DOC[6]: " *Yes, whole group has to be seen to move beyond zone, or not be seen for 30 mins*", and "*The intent of this provision is that since a group of marine mammals containing one calf has potential to contain more (and at distance it may be hard to follow movement of the cow/calf pair), the same precaution should apply to all the individuals*".

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans[7] (<300 m), any such bioacoustic detections will require an immediate shutdown of an active survey or will delay the start of operations, regardless of signal strength, or whether distance or bearing from the acoustic source has been determined. Shutdown of an activated acoustic source will not be required if visual observations by a qualified MMO confirm that the acoustic detection was of a species falling into the category of 'Other Marine Mammals'.

It is also recommended that observers monitor the area immediately beyond the 1.5 km mitigation zone. If SOC are approaching this zone, observers notify the seismic operator that a shutdown may be required.

### 4.6.2 Other Marine Mammals

If, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal 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 passed since the last detection of a New Zealand fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m of the source, and the mitigation zone remains clear.

If all mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, there will be no further delays to initiation of soft start.

Note: The presence of "Other Marine Mammals" within 200 m of the source will not result in a shutdown if the source is active, it can only result in a delay to start-up of the source.

MMOs should pay particular attention to the reactions and behaviour of NZ fur seals in close proximity to the source, with particular attention paid to their behaviour when the acoustic source is fired. The aim is to build knowledge of the effects of seismic noise on the behaviour of this species.

### 4.6.3 Mitigation posters and summary

Refer to Addenda 1 of this MMMP for posters detailing mitigation action procedures.

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[6] Email to BPM from Mr Tara Ross-Watt, DOC Senior Adviser - International and Marine; 17 December 2012.

[7] For the purposes of the Code, ultra-high frequencies are defined as those between 30 and 180 kHz - e.g. Maui's or Hector's dolphins.

## 5. Further Mitigation and Reporting Measures

In addition to the standard reporting outlined in Section 3, the following will be implemented during this survey and are over and above that identified in the Code. They have been agreed by DOC following discussions between OMV and DOC.

1) **Sound Transmission Loss Modelling (STLM) and validation**

   The results of STLM indicate that using a mitigation zone of 1.5 km for SOC with or without calf was appropriate. During the survey, the results of the STLM will be validated.

2) **Survey-specific mitigation zones**

   A mitigation zone of 1.5 km from the acoustic source will be applied to SOC with or without calf. A 200 m mitigation zone applies to 'other marine mammals'.

3) **Additional marine mammal observations outside Operational Area**

   A MMO will be on watch and recording marine mammal sightings during transit to and from the Operational Area during daylight hours and in good sighting conditions. Any marine mammal sightings outside the Operational Area will be recorded in the standardised DOC Off Survey Reporting form.

4) **Additional marine mammal species reporting requirements**

   MMOs will notify DOC immediately of any southern right whale, humpback whale or Hector's/Māui dolphin sightings.

5) **Reporting of entanglements and dead marine mammals**

   MMOs will be vigilant for entanglement incidents and will report any dead marine mammals observed at sea to DOC.

6) **Additional weekly reporting requirements**

   Weekly MMO reports to be provided to DOC and EPA.

7) **Necropsy of stranded marine mammals**

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

## 6. Notifications to DOC

If a situation arises that requires a more direct line of communication from the observers to DOC, then the MMO Team Leader is to first inform the Party Chief of the issue and intended action. The following table summarises the situations when DOC (in effect, the Director-General) should be notified immediately. During this survey, the first point of contact within DOC is Dave Lundquist (dlundquist@doc.govt.nz or ). If a response is required urgently then telephone, but in all other circumstances use email. Should Dave Lundquist be unavailable, Ian Angus (iangus@doc.govt.nz or is DOC's backup contact. If neither are available, please phone 0800DOCHOT and state the information as outlined in Section 3.2.

Please also refer to section 5 for any survey-specific instances when DOC should be notified.

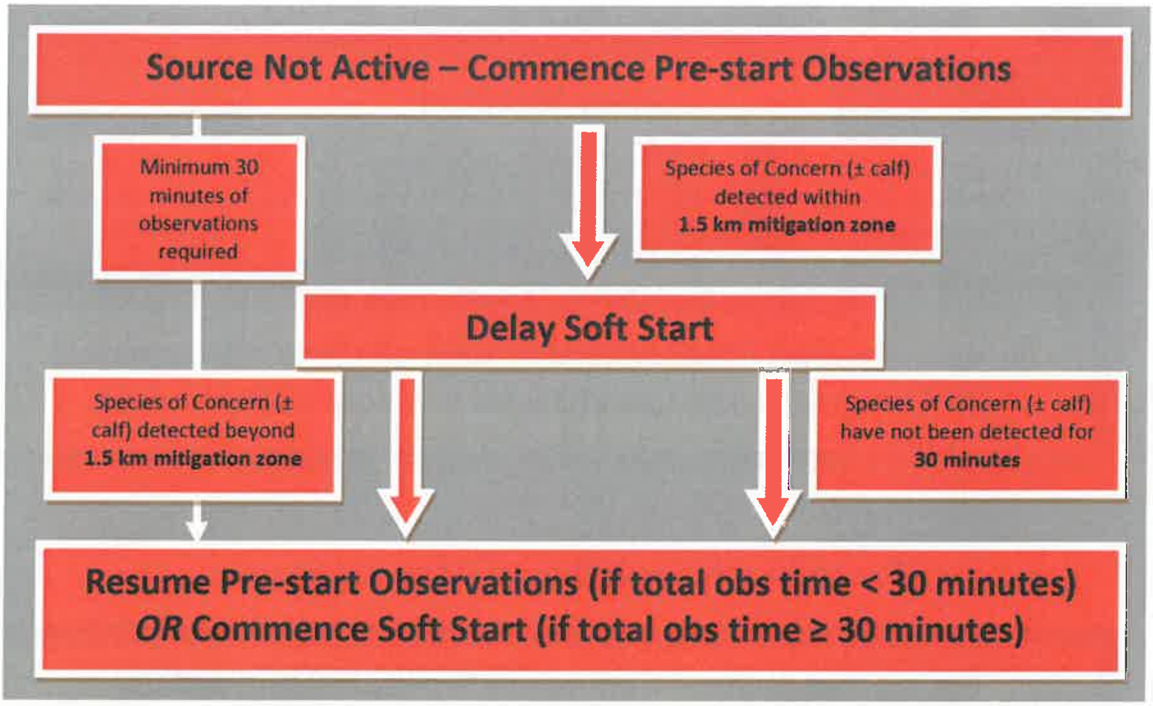
Table 1: Events that require DOC to be notified.

| **Situation** | **Timing of notification** | **Comments** |
|---|---|---|
| The PAM system becomes non-operational | Immediate | This refers to when both primary and backup systems are non-operational |
| Any instances of non-compliance with the Code | Immediate | This is a standard requirement under the Code and includes instances where the operational capacity notified in the MMIA is exceeded – refer Section 4.3.2 of this MMMP |
| MMOs consider that there are higher numbers of marine mammals encountered than what was summarised in the MMIA, including large numbers of migratory whales | Immediate | MMO Team Leader should report to DOC immediately if there appears to be a higher number of marine mammals encountered than summarised in the MMIA. This includes large numbers of whales on northward migration |
| If ground-truthing results indicate the mitigation zones are insufficient for providing protection to marine mammals from physiological or behavioural impacts | As soon as practicable | DOC is notified via email as soon as practicable with details of the ground-truthing results |
| If PAM is being repaired, and operations continue without active PAM for maximum of 2 hours 20 mins per event | As soon as practicable | DOC is notified via email as soon as practicable with the time and location in which operations began without an active PAM system (Code 4.1.2) |

# Addenda 1: Standard Mitigation Procedures – Good Sighting Conditions (poster format)

The following posters depict mitigation procedures. It is recommended they be posted in the instrument room, the PAM station and on the bridge. Operational flowcharts are also found in Appendix 4 of the Code.

## Species of Concern with/without Calf within 1.5 km of Acoustic Source



**Source Not Active – Commence Pre-start Observations**

Minimum 30 minutes of observations required

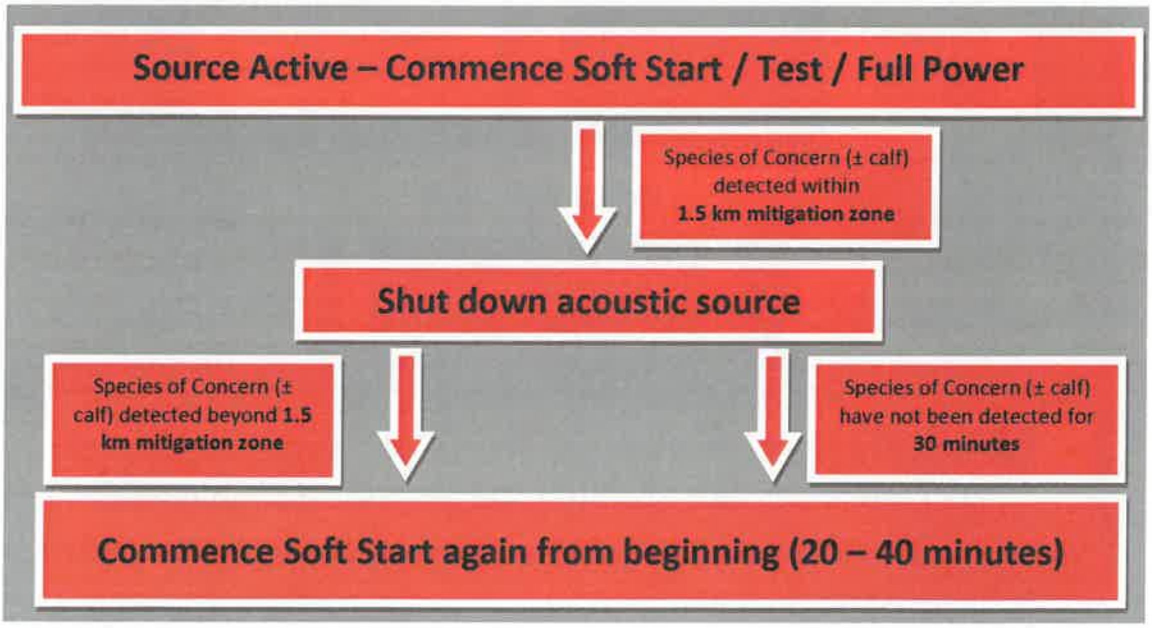
Species of Concern (± calf) detected within **1.5 km mitigation zone**

**Delay Soft Start**

Species of Concern (± calf) detected beyond **1.5 km mitigation zone**

Species of Concern (± calf) have not been detected for **30 minutes**

**Resume Pre-start Observations (if total obs time < 30 minutes)**
***OR* Commence Soft Start (if total obs time ≥ 30 minutes)**



**Source Active – Commence Soft Start / Test / Full Power**

Species of Concern (± calf) detected within **1.5 km mitigation zone**

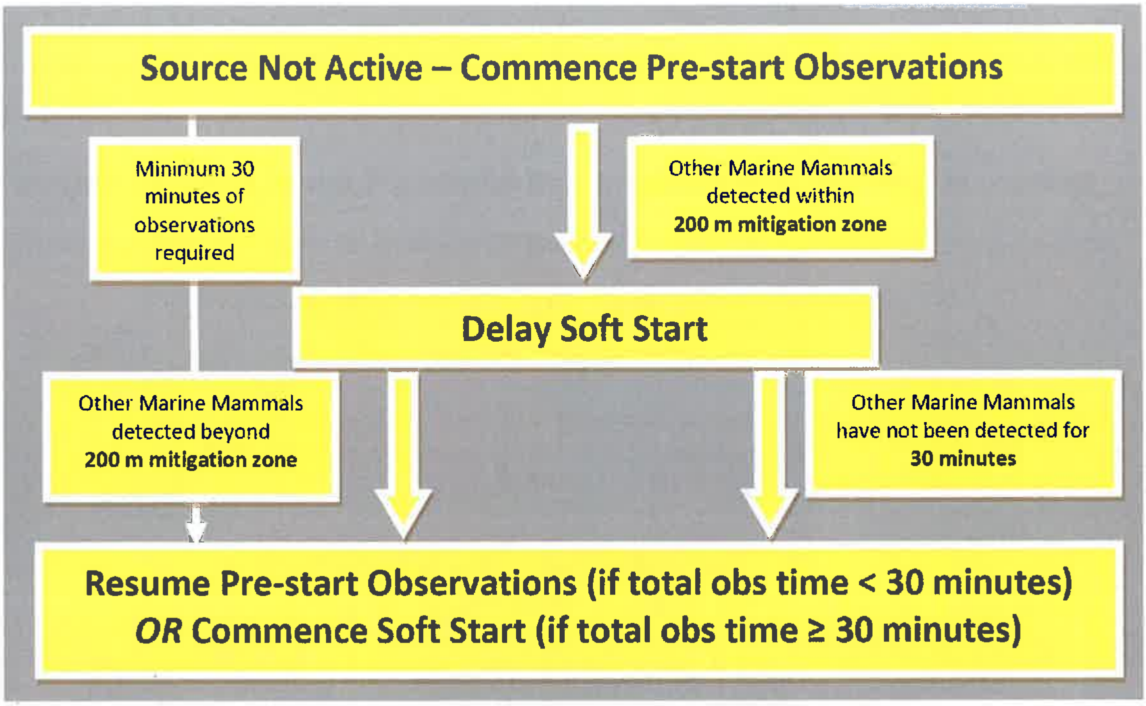
**Shut down acoustic source**

Species of Concern (± calf) detected beyond **1.5 km mitigation zone**

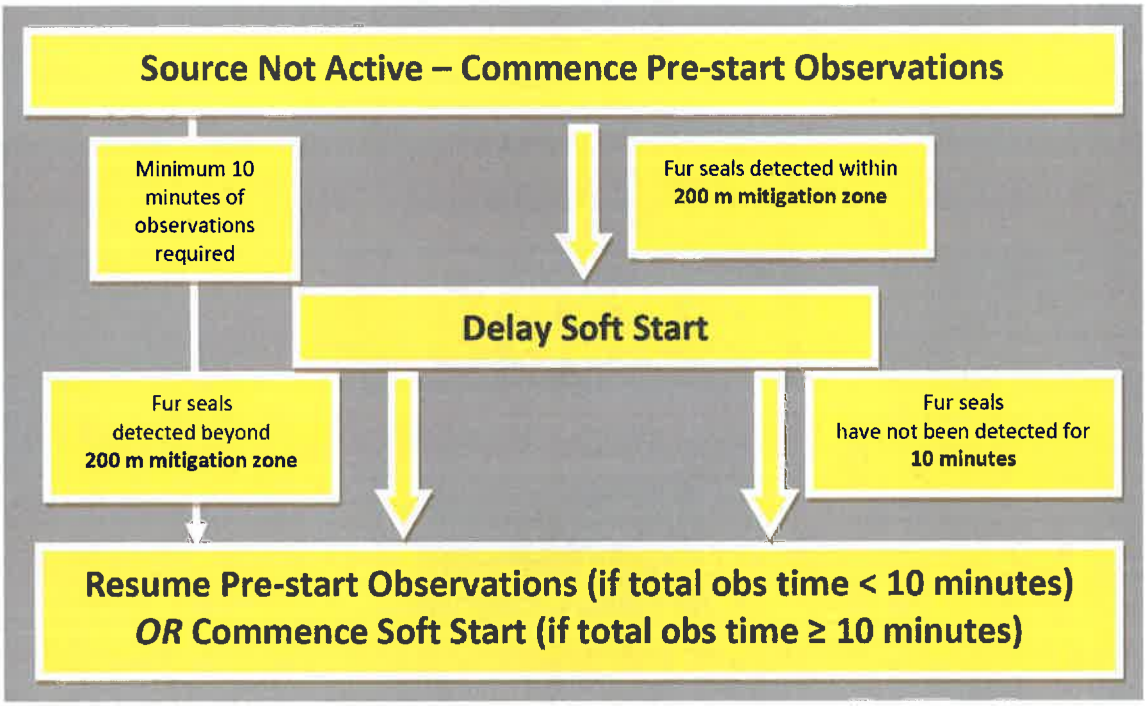
Species of Concern (± calf) have not been detected for **30 minutes**

**Commence Soft Start again from beginning (20 – 40 minutes)**

## Other Marine Mammals within 200 m of Acoustic Source (excluding fur seals)



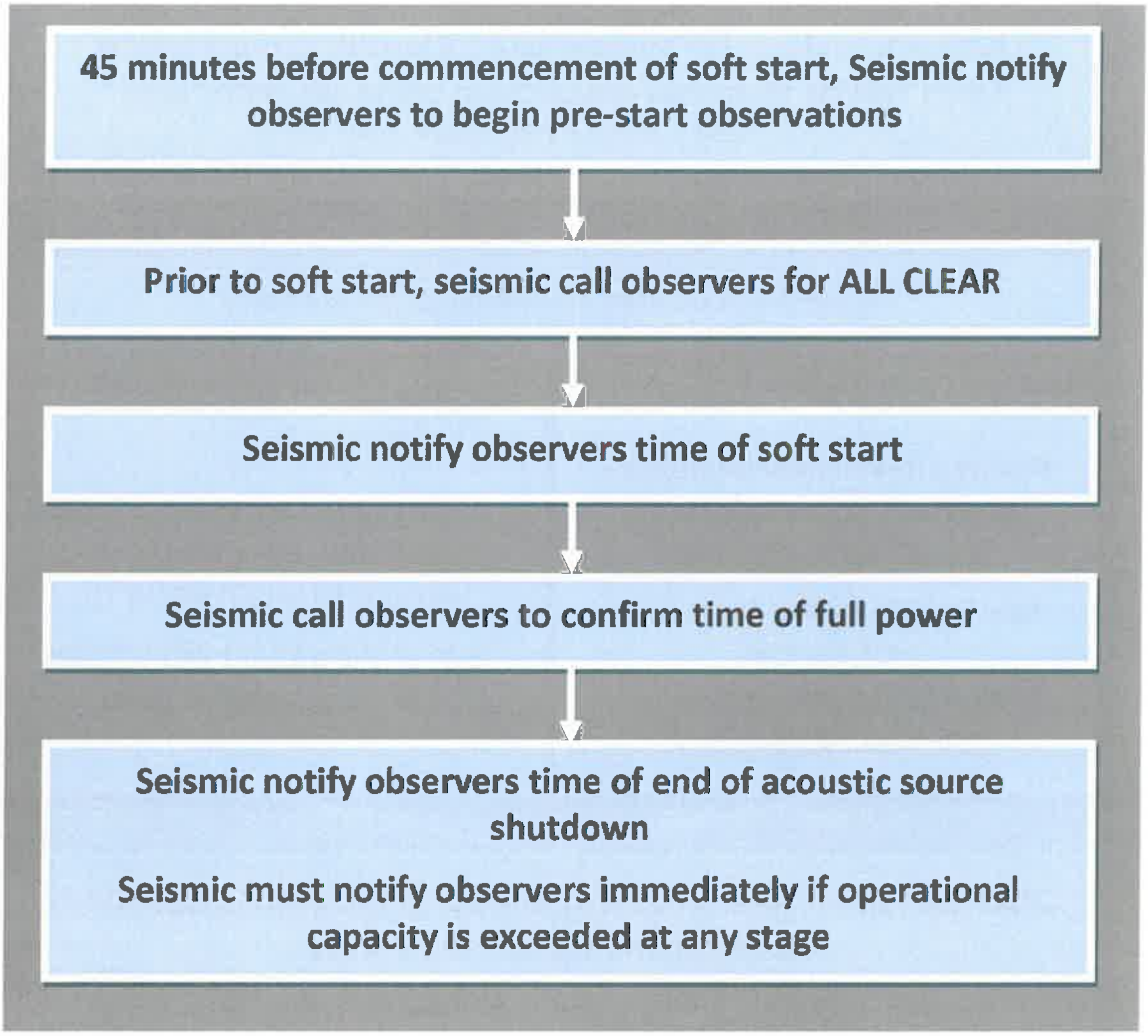
## Fur seals within 200 m of Acoustic Source



# Addenda 2: Recommended Communication Protocols (poster format)

Note: Seismic control room to immediately notify observers (MMO and PAMO) of any changes in the status of acoustic source.

## Normal Operations - No Marine Mammal Sighting/Detection



45 minutes before commencement of soft start, Seismic notify observers to begin pre-start observations

Prior to soft start, seismic call observers for ALL CLEAR

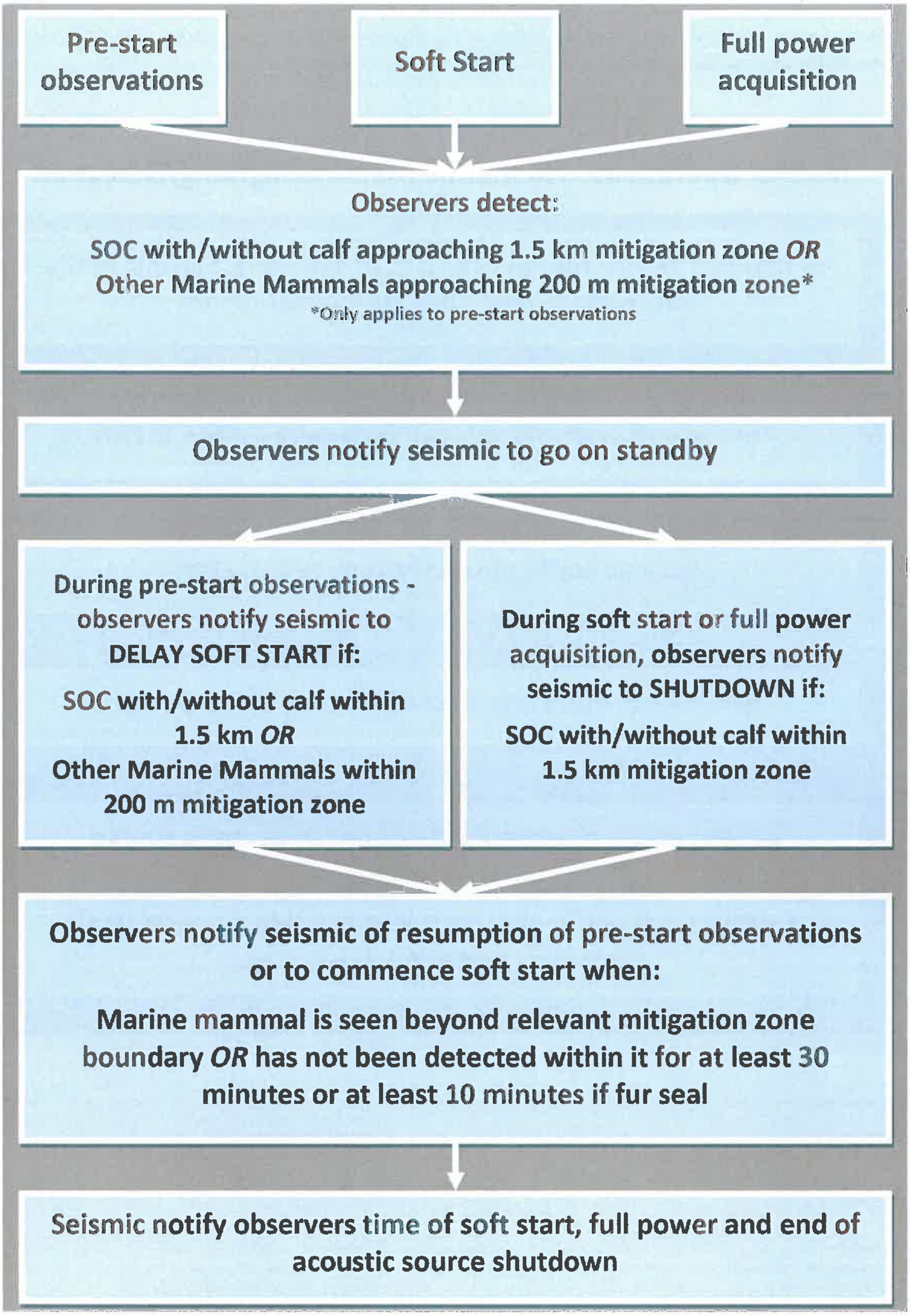
Seismic notify observers time of soft start

Seismic call observers to confirm time of full power

Seismic notify observers time of end of acoustic source shutdown

Seismic must notify observers immediately if operational capacity is exceeded at any stage

## Delayed Soft Start or Shutdown – Marine Mammal Sighting/Detection



Pre-start observations

Soft Start

Full power acquisition

Observers detect:

SOC with/without calf approaching 1.5 km mitigation zone *OR*
Other Marine Mammals approaching 200 m mitigation zone*
*Only applies to pre-start observations

Observers notify seismic to go on standby

During pre-start observations - observers notify seismic to DELAY SOFT START if:

SOC with/without calf within 1.5 km *OR*
Other Marine Mammals within 200 m mitigation zone

During soft start or full power acquisition, observers notify seismic to SHUTDOWN if:

SOC with/without calf within 1.5 km mitigation zone

Observers notify seismic of resumption of pre-start observations or to commence soft start when:

Marine mammal is seen beyond relevant mitigation zone boundary *OR* has not been detected within it for at least 30 minutes or at least 10 minutes if fur seal

Seismic notify observers time of soft start, full power and end of acoustic source shutdown

# Addenda 3: Operational Area coordinates

These coordinates have been loaded into VADAR for real time monitoring of vessel location and marine mammal detections relative to the Operational Area.

| **Operational Area (WGS84)** | |
|---|---|
| **Longitude (decimal degrees West)** | **Latitude (decimal degrees South)** |
| 173.45809 | -38.99962 |
| 173.45412 | -38.36624 |
| 173.81591 | -38.36523 |
| 173.81821 | -38.9118 |

# Addenda 4: Checklist for MMOs and PAMOs before acoustic source is put into water

MMOs and PAMOs to complete this checklist prior to the acoustic source being put into the water. MMO on watch to complete checklist during daylight hours, PAMO on watch to complete during hours of darkness.

**There will be at least one MMO (during daylight hours) and one PAMO on watch at all times while the acoustic source is in the water in the Operational Area.**

| | Task | Confirmed by? (MMO &/or PAMO) |
|---|---|---|
| 1 | Establish communications protocol with seismic control room and between MMO and/or PAMO on watch and ensure these are functioning | |
| 2 | Ensure MMOs, PAMOs and seismic control room are aware that the acoustic source must not enter the water within the Operational Area without MMO (daylight hours) and PAMO (24 hours) on watch | |
| 3 | Is seismic control room aware that they need to inform MMO and/or PAMO at what time they intend to place seismic source into the water? | |
| 4 | MMO (daylight hours) informs PAMO that they are on watch prior to acoustic source being placed in water and endorses go ahead for acoustic source to be placed in water<br>PAMO has acknowledged this? | |
| 5 | PAMO (24 hours) informs MMO that they are on watch prior to acoustic source being placed in water and endorses go ahead for acoustic source to be placed in water<br>MMO has acknowledged this? | |
| 6 | MMO (during daylight hours) informs seismic control room that MMO and PAMO are on watch and that acoustic source can be placed in water.<br>Seismic control room acknowledged this?<br>If during hours of darkness, PAMO undertakes this task | |
| 7 | Seismic control room informs MMO and/or PAMO when the acoustic source enters the water | |

# Addenda 5: Species of Concern as defined in the Code

| **Common name** | **Latin name** |
|---|---|
| Andrew's beaked whale | *Mesoplodon bowdoini* |
| Antarctic minke whale | *Balaenoptera bonarensis* |
| Arnoux's beaked whale | *Berardius arnuxii* |
| Blainville's beaked whale | *Mesoplodon densirostris* |
| Blue whale | *Balaenoptera musculus* |
| Bottlenose dolphin | *Tursiops truncatus* |
| Bryde's whale | *Balaenoptera edeni* |
| Cuvier's beaked whale | *Ziphius cavirostris* |
| Dwarf Minke whale | *Balaenoptera acutorostrata subsp.* |
| Dwarf sperm whale | *Kogia simus* |
| False killer whale | *Pseudorca crassidens* |
| Fin whale | *Balaenoptera physalus* |
| Ginkgo-toothed whale | *Mesoplodon ginkgodens* |
| Gray's beaked whale | *Mesoplodon grayi* |
| Hector's beaked whale | *Mesoplodon hectori* |
| Hector's dolphin | *Cephalorhynchus hectori* |
| Humpback whale | *Megaptera novaeangliae* |
| Killer whale | *Orcinus orca* |
| Long-finned pilot whale | *Globicephala melas* |
| Māui's dolphin | *Cephalorhynchus hectori maui* |
| Melon-headed whale | *Peponocephala electra* |
| New Zealand sea lion | *Phocarctos hookeri* |
| Pygmy/Peruvian beaked whale | *Mesoplodon peruvianus* |
| Pygmy blue whale | *Balaenoptera musculus brevicauda* |
| Pygmy killer whale | *Feresa attenuata* |
| Pygmy right whale | *Caperea marginata* |
| Pygmy sperm whale | *Kogia breviceps* |
| Sei whale | *Balaenoptera borealis* |
| Shepherd's beaked whale | *Tasmacetus shepherdi* |

| | |
|---|---|
| Short-finned pilot whale | *Globicephala macrorhynchus* |
| Southern Bottlenose whale | *Hyperoodon planifrons* |
| Southern right whale | *Eubalaena australis* |
| Southern right whale dolphin | *Lissodelphis peronii* |
| Sperm whale | *Physeter macrocephalus* |
| Strap-toothed whale | *Mesoplodon layardii* |
| True's beaked whale | *Mesoplodon mirus* |