TARANAKI AND MĀUI EAD CHECKSHOT SURVEYS

Marine Mammal Impact Assessment

Prepared for:

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BASIS OF REPORT

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EXECUTIVE SUMMARY

OMV New Zealand Limited (**OMV New Zealand**) has been granted regulatory approval to commence the Taranaki Exploration and Appraisal Drilling (**EAD**) Programme within the Taranaki Basin, which is proposed to commence in November 2019. Additionally, OMV Taranaki Limited (**OTL**) is in the final stages of regulatory approval for the Māui EAD Programme, and it is intended that the EAD Programme will commence in the Māui Field from Q1, 2020. OMV New Zealand and OTL are subsidiary companies of the OMV Group, and for the purpose of this application will be collectively referred to as **OMV**. The purpose of the EAD Programmes is to determine the presence of hydrocarbons within a number of identified subsurface geological structures and to investigate the potential for future development of discovered hydrocarbons within OMV's permit areas in the Taranaki Basin.

Checkshot surveys may be undertaken in the event that hydrocarbon accumulations are discovered in the Taranaki and Māui EAD Programmes (**Taranaki Checkshot Surveys**). In the event that no hydrocarbon accumulations are discovered, no checkshot survey is likely to be required; however, that is not known until each well has been drilled and appropriate formation evaluation has been undertaken. The objective of the Taranaki Checkshot Surveys is to ascertain further information about the velocity characteristics of the strata penetrated by the wellbore, in order to accurately translate between sonic/density properties measured within each well and acoustic data from seismic surveys recorded in the vicinity of each well.

Under the Exclusive Economic Zone and Continental Shelf (Environmental Effects - Permitted Activities) Regulations (**Permitted Activities Regulations**), seismic operations in New Zealand's Exclusive Economic Zone (**EEZ**) must comply with the Department of Conservation's (**DOC**) 2013 Code for Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (**Code of Conduct**). Under the Code of Conduct, a Marine Mammal Impact Assessment (**MMIA**) is required in order to describe the proposed seismic operations, provide a description of the baseline environment, identify any potential environmental effects from the seismic operations, and to specify any proposed mitigation measures to minimise environmental effects. Where seismic activities are undertaken within an Area of Ecological Importance, sound transmission loss modelling is also required.

The initial three wells planned in the Taranaki and Māui EAD Programmes are Gladstone-1 (within PEP 57075), Toutouwai-1 (within PEP 60093), and Māui-8 (within PML 381012). Three Operational Areas have been identified around these three well locations for the purpose of the MMIA for the Taranaki and Māui EAD Programmes. Supplementary MMIAs will be submitted if additional wells are required in these EAD Programmes, specific to the characteristics of those locations. An Environmental Risk Assessment (**ERA**) process has been utilised within this MMIA to assess the significance of any predicted effects on biological, socio-economic, and cultural environments of relevance to the three Operational Areas. Stakeholder engagement has been carried out by OMV as part of their wider Taranaki and Māui EAD Programmes and Cultural Advisory Groups.

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Utilising data within DOC's stranding and sighting database, OMV's knowledge from working in the Taranaki Basin and previous seismic surveys acquired in the Taranaki Basin, and knowledge of migration paths and habitat preferences of each marine mammal species (obtained from published scientific literature), the following marine mammals are *likely* to be present within the Operational Areas: Antarctic minke whale, bottlenose dolphin, common dolphin, Cuvier's beaked whale, dusky dolphin, dwarf minke whale, false killer whale, Gray's beaked whale, killer whale, long-finned pilot whale, pygmy blue whale, pygmy sperm whale, sperm whale, and New Zealand fur seals. Andrew's beaked whale, Bryde's whale, Hector's dolphin, Māui's dolphin, pygmy right whale, Shepherd's beaked whale, southern bottlenose whale, southern right whale, spectacled porpoise, and strap-toothed whale are considered to have a *possible* presence within the Operational Areas.

OMV's proposed checkshot surveys fall within the classification of a Level 1 marine seismic survey due to the source volume (i.e. > 427 in^3). Compliance with the Code of Conduct for a Level 1 marine seismic survey is the primary mitigation measure that OMV will employ during the Taranaki Checkshot Surveys. The full protocol of operational procedures and control measures that will be followed during the Taranaki Checkshot Surveys is detailed within the Marine Mammal Mitigation Plan (**MMMP**, Appendix D) which will provide a working document during the checkshot surveys. The following specific actions are particularly important with regard to operating in accordance with the Code of Conduct:

- Where available, two qualified Marine Mammal Observers (**MMO**) and two qualified Passive Acoustic Monitoring (**PAM**) Observers will be present for the duration of the Taranaki Checkshot Survey. In the event that two qualified MMOs or PAM Operators are unable to be engaged, the Code of Conduct provides for a qualified observer to act in a supervisor/mentor role to a trained observer;
- The MMOs will be present onboard the MODU, and the PAM Operators will be present onboard a support vessel, to visually and acoustically detect for the presence of any marine mammals prior to the commencement of the checkshot surveys and for the duration of the surveys. Due to the noise interference from the actively-operating Mobile Offshore Drilling Unit (**MODU**), PAM (Appendix B) will be deployed from the support vessel, which will circle the MODU within a radius of approximately 1 km;
- Seismic operations will be delayed if marine mammals are detected within the relevant mitigation zones as defined in the Code of Conduct;
- The power of the acoustic source will be gradually increased during a 'soft start' over a period of 20 minutes prior to any seismic operations to ensure any undetected marine mammals have an opportunity to leave the area before full operational power is reached; and
- The acoustic source will be shut down if a marine mammal enters the defined mitigation zones.

Sound Transmission Loss Modelling (**STLM**, Appendix A) has been used to verify the sound thresholds for the standard mitigation zones specified within the Code of Conduct. The short-range modelling prediction demonstrates that for all three proposed well locations, the maximum received Sound Exposure Level (**SEL**) is predicted to comply with the limits of 186 dB re 1μPa^2·s at 200 m, and 171 dB re 1μPa^2·s at 1.0 km and 1.5 km.

This MMIA identifies the potential environmental effects from the Taranaki Checkshot Surveys and describes the mitigation measures that will be implemented so that any potential effects are reduced to a level that is as low as reasonably practicable. While the focus of this MMIA is on marine mammals, potential effects on other environmental and socio-economic receptors have also been considered.

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Overall, the predicted effects of the Taranaki Checkshot Surveys are considered to be sufficiently managed by the proposed mitigation measures, predominantly compliance with the Code of Conduct. Due to the small volume acoustic source that will be utilised during each survey, behavioural effects on marine mammals will be restricted to within 200 m of the acoustic source, as demonstrated by STLM. The STLM results have confirmed that the proposed Taranaki Checkshot Survey is compliant with the requirements stipulated for SEL thresholds within the Code of Conduct. Discharges associated with the MODU and support vessel, the presence of these vessels within each Operational Area, and the potential for interactions with other marine users have been covered under the appropriate Marine Consents for the Taranaki and Māui EAD Programmes.

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ABBREVIATIONS AND DEFINITIONS

AIS	Automatic Identification System
AOI	Area of Interest
CMA	Coastal Marine Area
Code of Conduct	Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations
COLREGS	International Regulations for the Prevention of Collisions at Sea 1972
dB	Decibels
DOC	Department of Conservation
EAD	Exploration and Appraisal Drilling
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EPA	Environmental Protection Authority
ERA	Environmental Risk Assessment
FMA	Fisheries Management Area
FNZ	Fisheries New Zealand
FPSO	Floating Production Storage and Offloading Unit
Hz	Hertz
IUCN	International Union for Conservation of Nature
MARPOL	International Convention for the Prevention of Pollution from Ships 1973 as Modified by the Protocol of 1978
MMIA	Marine Mammal Impact Assessment
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Mammal Observer
MODU	Mobile Offshore Drilling Unit
MPA	Māui Platform Alpha
MPB	Māui Platform Bravo
NABIS	National Aquatic Biodiversity Information System
NIWA	National Institute of Water and Atmospheric Research
OMV	OMV New Zealand Limited
OTL	OMV Taranaki Limited
PAM	Passive Acoustic Monitoring
PEP	Petroleum Exploration Permit

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Permitted Activities Regulations	Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013
PML	Petroleum Mining Licence
QMS	Quota Management System
RMA	Resource Management Act 1991
SEL	Sound Exposure Level

1 Introduction

OMV New Zealand Limited (**OMV**) has been granted regulatory approval to commence the Taranaki Exploration and Appraisal Drilling (**EAD**) Programme within the Taranaki Basin, which is proposed to commence in November 2019. Additionally, OMV Taranaki Limited (**OTL**) is in the final stages of regulatory approval for the Māui EAD Programme, and it is intended that the EAD Programme will commence in the Māui Field from Q1 2020. OMV New Zealand and OTL are subsidiary companies of the OMV Group, and for the purpose of this application will be collectively referred to as **OMV**. The purpose of the EAD Programmes is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the potential for future development of any discovered hydrocarbons within OMV's permit areas in the Taranaki Basin.

There are a number of regulatory approvals that OMV is required to have in place prior to commencing the Taranaki and Māui EAD Programmes, split across various pieces of legislation. The substantive approval for the Taranaki EAD Programme (i.e. the non-notified Marine Consent) was granted on 15 January 2019. At the time of submission for this Marine Mammal Impact Assessment (**MMIA**), the Māui EAD Programme Marine Consent and Marine Discharge Consent Application will be lodged with the Environment Protection Authority (**EPA**) early December 2019.

Initial drilling activities associated with the Taranaki EAD Programme will be undertaken within Petroleum Exploration Permit (**PEP**) 57075 and PEP 60093 (Gladstone-1 and Toutouwai-1 respectively). All drilling activities associated with the Māui EAD Programme will be undertaken within Petroleum Mining Licence (**PML**) 381012 (initially Māui-8).

Checkshot surveys may be undertaken if hydrocarbon accumulations are discovered at Gladstone-1, Toutouwai-1, or Māui-8. In the event that no hydrocarbon accumulations are discovered, no checkshot surveys are likely to be required; however, that is not going to be known until each well has been drilled and appropriate formation evaluation has been undertaken. The objective of the checkshot surveys is to ascertain further information about the velocity characteristics of the strata penetrated by the wellbore, in order to accurately translate between sonic/density properties measured within each well and acoustic data from seismic surveys recorded in the vicinity of each well. The Gladstone-1, Toutouwai-1 and Māui-8 wells are located in the Taranaki Bight in water depths of 135 m, 131 m and 110 m respectively. Planned well characteristics for each well are provided in **Table 1** below. Due to the geographic distribution of the wells across the North and South Taranaki Bight, three Operational Areas have been defined and assessed within this MMIA (**Figure 1**). These Operational Areas are also the areas where the acoustic source is able to be active based on the assessment of effects considered within this MMIA.

Table 1 Planned Well Characteristics for Gladstone-1, Toutouwai-1 and Māui-8 wells

Well	Water Depth (m bMSL)	Target Depth (m)	Last Casing Depth (m)	Length of Open Hole (m)
Gladstone-1	135	3,079	1,515	1,550
Toutouwai-1	131	4,361	1,520	2,841
Māui-8	110	3,410	1,100	2,310

The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZ Act**) came into force in 2013 and established the first comprehensive environmental consenting regime for activities in New Zealand's Exclusive Economic Zone (**EEZ**) and Continental Shelf. Under the EEZ Act, a marine seismic survey is classified as a permitted activity and is therefore included within the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (**Permitted Activities Regulations**). The Permitted Activities Regulations permit seismic surveys providing the operator undertaking the survey complies with the Department of Conservation (**DOC**) 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (**Code of Conduct**) or obtains a marine consent from the EPA.

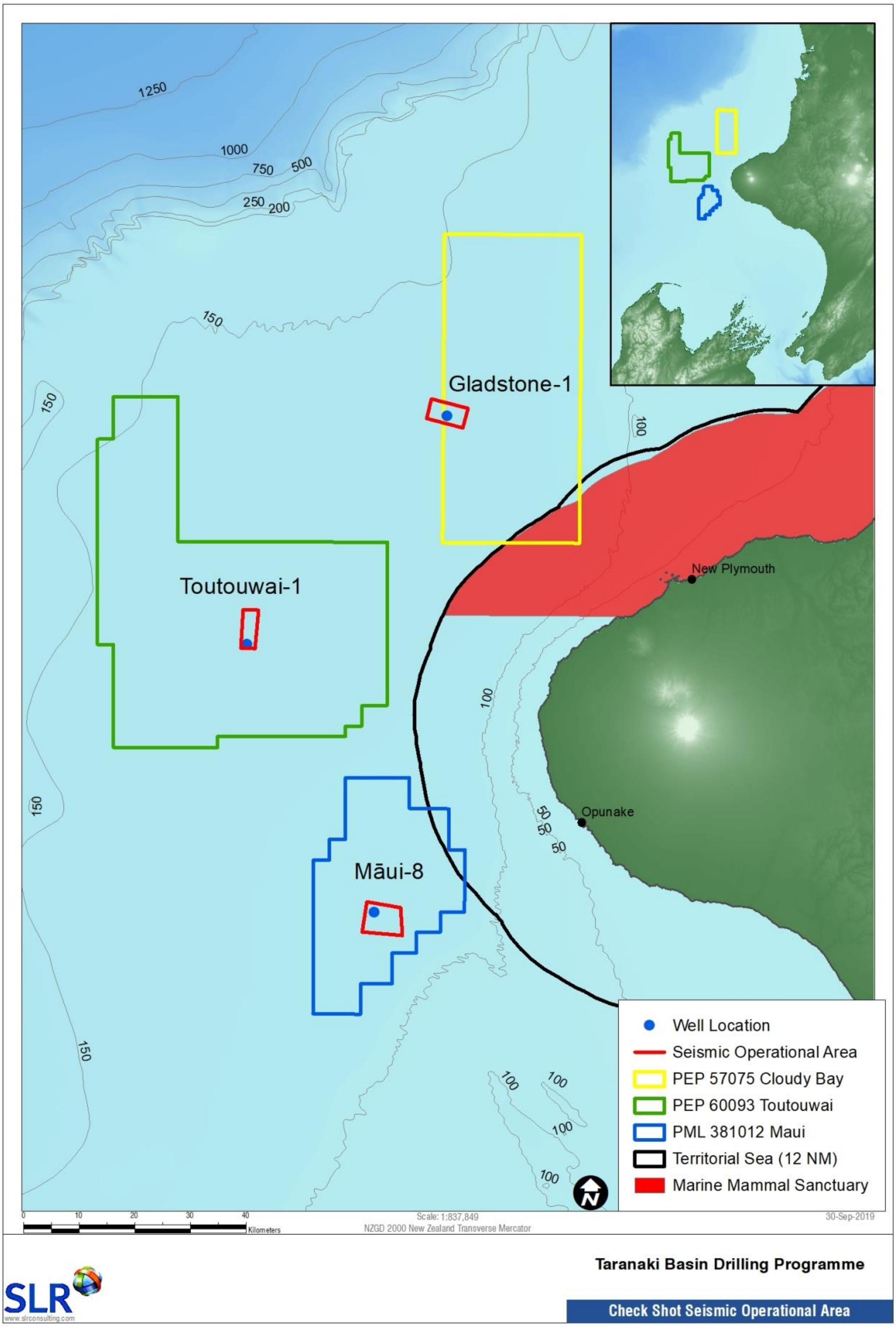
In waters outside of the EEZ (such as within the Coastal Marine Area (**CMA**)) compliance with the Code of Conduct remains largely voluntary; except in cases where the Regional Coastal Plan also requires compliance with the Code of Conduct. Taranaki Regional Council is in the process of updating its Regional Coastal Plan such that seismic surveying will be considered a controlled activity allowing for resticitions in addition to the Code of Conduct. In time it is likely that other councils will adopt a similar approach as well. The Code of Conduct is summarised in **Section 3.5**. All activities associated with the Taranaki and Māui EAD Programmes will occur within the EEZ.

This MMIA is an integral component to ensure that OMV undertakes the Taranaki Checkshot Surveys in adherence to the Permitted Activities Regulations and Code of Conduct. The Code of Conduct requires Sound Transmission Loss Modelling (**STLM**) to be undertaken for any seismic surveys that will operate within an Area of Ecological Importance. The locations of the Operational Areas within the Area of Ecological Importance are discussed in **Section 3.5.3**. STLM provides a prediction of the received Sound Exposure Levels (**SELs**) over a range of a few kilometres from the array sound location in order to assess whether the proposed survey complies with the Code of Conduct mitigation zones. As well as operating to the requirements of the Code of Conduct throughout the duration of each checkshot survey, OMV will operate in accordance with relevant New Zealand legislation, international conventions, and their internal environmental standards.

The Taranaki Checkshot Surveys are classified as a 'Level 1' survey by the Code of Conduct (i.e. >427 in^3 acoustic source), and OMV will comply with all relevant requirements while conducting each checkshot survey. The Code of Conduct requirements for a Level 1 marine seismic survey are outlined in **Section 3.5**. The protocol that the Marine Mammal Observers (**MMO**) and Passive Acoustic Monitoring (**PAM**) Operators will follow during the Taranaki Checkshot Surveys is outlined in the Marine Mammal Mitigation Plan (**MMMP**) which is included as **Appendix D**.

During the preparation of the MMIA for the Taranaki Checkshot Surveys, an extensive review of literature and existing data on the environment surrounding the three Operational Areas has been undertaken. A description of the existing environment is provided throughout **Section 5**. Published scientific literature has been used within **Section 6** in order to provide an assessment of the potential effects of each checkshot survey on the fauna described in **Section 5.2**. A full list of references used throughout this MMIA is provided in **Section 8**.

Figure 1 Location of Gladstone-1, Toutouwai-1, and Māui-8 wells and Associated Operational Areas



2 Project Description

2.1 Marine Seismic Surveys – Overview

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

2.1.1 Checkshot Surveys

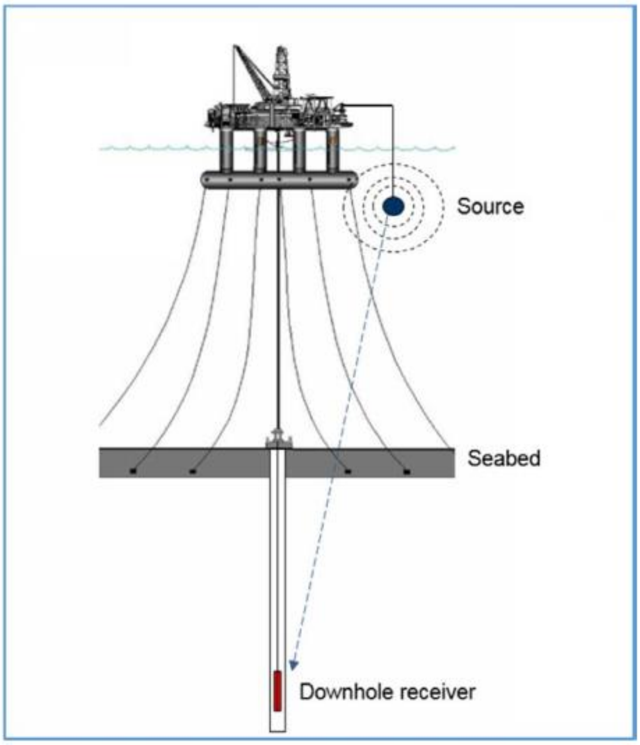
Checkshot surveys are a form of borehole seismic survey used to identify specific characteristics about geological features below the seafloor that have been intersected during drilling activities. The characteristics of the geological features are identified by the differing reflective properties of sound waves off the various subsurface rock strata.

During a survey the sound energy source (acoustic source array) is lowered from the MODU to approximately 5 m below the surface of the ocean, and when it is activated the acoustic source releases a sound wave generated by the release of compressed air from the array. This pulse is focussed downwards through the water column and into the sub-surface beneath the MODU. At each point where different geological strata exist, different densities and velocity discontinuities cause a portion of the energy to be reflected/modified. The returned sound waves are recorded through a downhole receiver which is located within the recently completed well bore at known depths.

Typically, the acoustic source emits the first signal when the receiver is at the deepest point in the well, and then after the returned signal is received the receiver is raised a distance up the wellbore and the process is repeated. This continues until the receiver reaches a point within the subsurface where the signal received is too weak to be recorded accurately (typically due to the acoustic signal having to penetrate through multiple casing strings to reach the receiver inside the wellbore). Signals recorded by the receiver are amplified and digitised to facilitate interpretation of the geological structure and strata through which the well has been drilled.

The checkshot survey data provides a profile of the rock structure surrounding the well down to a depth just below the completed depth of the well. A schematic of a checkshot survey configuration is shown in **Figure 2**.

Figure 2 Schematic of an Operational Marine Checkshot Survey



2.1.2 Underwater Sound

Underwater sound has two primary measures:

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

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

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

The ocean is a naturally noisy environment. Natural sound inputs include wind, waves, marine life, underwater volcanoes and earthquakes. Man-made sounds such as shipping, fishing, marine construction, dredging, military activities and sonar further add to the underwater noise profile. The sound levels produced during a seismic survey are comparable to a number of naturally occurring and man-made sources (**Table 2**).

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

Note: The sound levels provided above for a seismic array refers to that from a full seismic survey. As the volume of the acoustic source that will be used for the Taranaki Checkshot Surveys is considerably smaller than that used in a full seismic survey, the noise output during the Taranaki Checkshot Surveys will be much less than that of a full-scale seismic survey.

2.1.3 The Acoustic Source

The acoustic source is lowered into the water from a crane on the MODU above and slightly to the side (approximately 49.5 m) of the drilled well. The source is comprised of two high-pressure chambers: an upper control chamber and a discharge chamber. High-pressure bottled nitrogen (compressed) on-board the MODU is continuously fed to each source in the array, forcing a piston downwards. The chambers then fill with high-pressure air while the piston remains in the closed position.

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

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

Acoustic sources used by the oil and gas industry are designed to emit most of their energy at low frequencies, typically 20 – 50 Hz with declining energy at frequencies above 200 Hz (Popper et al., 2014). Total source levels range from ~222 – 264 dB when measured relative to a reference pressure of one micro-pascal (re 1µPa-m_{p-p}) (Richardson et al., 1995), with the proposed source having a peak sound pressure level (Pk-SPL) of 7.3 Bar (237.4 dB re 1µPa @ 1m) and peak-to-peak sound pressure level (Pk-Pk SPL) of 14.1 Bar (243 dB re 1µPa @ 1m).

The triple acoustic source cluster that will be used by OMV during the Taranaki Checkshot Surveys is shown in **Figure 3** below.

Figure 3 Triple Acoustic Source Cluster Inside Standard Delta Deployment Frame

2.2 Taranaki EAD and Māui EAD Checkshot Surveys

Checkshot surveys will be undertaken if, during the drilling of the Gladstone-1, Toutouwai-1 or Māui-8 exploration wells, there are indications of potentially-commercial accumulations of hydrocarbons present. The acoustic source will consist of three 150 in^3 sub-sources, with an effective total volume of 450 in^3. The acoustic source will be deployed from a crane and positioned approximately 5 m below the sea surface, while a receiver will be lowered to the bottom of the well on a wireline. The acoustic source will have an operating pressure of approximately 2,000 psi.

The survey specifications for the OMV Taranaki Checkshot Surveys are provided in **Table 3**.

Table 3 Checkshot Survey Specifications

Parameter	Specifications
Source type	Triple Source cluster array
Source volume	450 in^3
Maximum predicted output	14.1 Bar = 243 dB re 1μPa @ 1m (peak to peak)
Number of sub-arrays per source	3
Nominal operating pressure	2000 psi firing pressure, 2400 psi accumulator pressure
Source Frequency	10 Hz Approximately 90 seconds on average between shots
Source Depth	4.9 m

Marine mammal observations and Passive Acoustic Monitoring (**PAM**) for the acoustic detections of marine mammals will be implemented during the checkshot surveys. These are discussed in more detail in **Section 3.5**. Due to the interfering noise that is emitted from the actively-operating MODU, the PAM system will be deployed from a support vessel, with the support vessel circling the MODU at a distance of approximately 1 km.

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

A checkshot survey could take up to 12 hours to complete, depending on the particular well characteristics (i.e. depth) and required information. OMV has undertaken checkshot surveys during previous exploration drilling programmes in the Taranaki Basin, and these have ranged between 2.7 and 11.5 hours for completion, with the number of activated shots ranging from 89 - 332.

2.3 Navigational Safety

The Taranaki Checkshot Surveys will occur following the completion of drilling operations at each well (if required), during which time the MODU will have been in position for between 25 and 50 days. Other marine users will be aware of the presence of the MODU through a Notice to Mariners and coastal navigation warnings broadcast daily on maritime radio. A 500 m non-interference exclusion zone will exist around the MODU to exclude other marine users from the immediate vicinity. The MODU and support vessel will have Automatic Identification (**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. The MODU and support vessels will display the appropriate lights and day shapes while on location.

A MODU would not be present at any well location without all relevant regulatory approvals being in place (including marine consent and marine discharge consent) in accordance with the EEZ Act, for which an extensive engagement and notification process would already have been undertaken.

2.4 Survey Design Considerations and Alternatives

The proposed acoustic source array configuration and the produced sound levels for the possible checkshot surveys were selected in order to provide sufficient power to fulfil the survey objective, whilst minimising excessive acoustic noise entering into the surrounding marine environments. A total source level of 450 in^3, comprising three individual 150 in^3 sources firing in unison in a cluster, has been chosen by OMV as a suitable power level to achieve the survey objectives.

The Operational Areas are at least 39 km from the Taranaki coastline and the source will be fixed in location at each well site.

Given there are many variables at play that will determine if and when a checkshot survey is undertaken, it is possible that a checkshot survey could occur in any season. As such an assessment has been made for all potential overlaps with whale migrations in and through the offshore Taranaki area that could possibly be affected by increased underwater noise. For example, acquiring the survey(s) over the summer period could increase the potential for observations of blue whales which are known to feed on aggregations of krill in the South Taranaki Bight over the summer months. Whereas in winter, there is the migration of the humpback whales through the Cook Strait and Taranaki region on their way to tropical breeding grounds. As a result, the Environmental Risk Assessment (**ERA**) that is incorporated into this MMIA has taken into account any potential effects on the marine environment from the checkshot surveys throughout the year.

3 Legislative Framework

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

The legislative framework that relates to the proposed checkshot surveys at Gladstone-1, Toutouwai-1 and Māui-8 is described below.

3.1 Crown Minerals Act 1991

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

The Crown Minerals Act 'regime' comprises the Crown Minerals Act 1991, two minerals programmes (one for petroleum and one for other Crown-owned minerals), and associated regulations. Together, these regulate the exploration and production of Crown-owned minerals (NZP&M, 2015).

The Petroleum Minerals Programme 2013 applies to all applications for permits for petroleum activities. It sets out the policies and procedures to be followed for the allocation of petroleum resources, while the requirements to be met by permit holders are defined in the regulations. The programme also defines specific requirements for engagement with iwi and hapū, including the matters that must be consulted on (such as all permit applications) and the engagement principles. Engagement that was undertaken by OMV in relation to the Taranaki Checkshot Surveys is detailed in **Section 4**.

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

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

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

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

- **Permitted** – the activity can be undertaken provided the operator meets the conditions specified within the regulations. Seismic surveys fall within this classification and the conditions state that the person undertaking the activity must comply with the 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 70 working days in which to process the application;
- **Discretionary** – the activity may be undertaken if the applicant obtains a marine consent from the EPA. The consent application will be notified, submissions will be invited, and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 170 working days in which the EPA must assess the consent application; and
- **Prohibited** – the activity may not be undertaken.

DOC administers the Code of Conduct while the EPA enforces the EEZ Permitted Activities regime, including monitoring for compliance with the seismic surveying Code of Conduct and may conduct audits of the MODU and survey equipment before, during or after each survey. The EPA has the authority to take enforcement action in relation to any non-compliant activities during the proposed checkshot surveys.

3.3 Marine Mammals Protection Act 1978

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

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

The closest Marine Mammal Sanctuary to the Taranaki Checkshot Surveys is the West Coast North Island Marine Mammal Sanctuary, which lies approximately 25 km inshore of the closest Operational Area (Gladstone-1) (**Figure 1**). Due to the localised effects of the checkshot surveys, there will be no impacts to Marine Mammal Sanctuaries.

3.4 International Regulations and Conventions

A number of international regulations and conventions will be adhered to during each checkshot survey, for example the International Regulations for the Prevention of Collisions at Sea 1972 (**COLREGS**) and International Convention for the Prevention of Pollution from Ships 1973 (**MARPOL**); however, these have been covered in detail under the relevant Marine Consent applications for the wider Taranaki and Māui EAD Programmes and are therefore not described further within this MMIA given that the MODU will already be on location under a previously consented activity in accordance with the EEZ Act.

3.5 Code of Conduct

The Code of Conduct was developed by DOC in consultation with a broad range of stakeholders in marine seismic survey operations in New Zealand to manage the potential impacts of seismic operations on marine mammals. Throughout the development of the Code of Conduct, DOC worked with stakeholders who participated in various working and review groups and provided submissions and contributed to the review process. Stakeholders involved in the development of the Code of Conduct include observers, researchers, operators and regulators. Under the Permitted Activities Regulations, any operator proposing to undertake seismic surveys within the waters of the EEZ must comply with the requirements within the Code of Conduct. In waters outside of the EEZ compliance with the Code of Conduct remains largely voluntary; except in cases where the Regional Coastal Plan also requires compliance with the Code of Conduct. Taranaki Regional Council is in the process of updating its Regional Coastal Plan such that seismic surveying will be considered a controlled activity allowing for restrictions in addition to the Code of Conduct, and in time it is likely that other councils will adopt this approach as well.

The Code of Conduct aims to:

- Minimise disturbance to marine mammals from seismic survey activities;
- Minimise noise in the marine environment arising from seismic survey activities;
- Contribute to the body of scientific knowledge on the physical and behavioural impacts of seismic surveys on marine mammals through improved, standardised observations and reporting;
- Provide for the conduct of seismic surveys in New Zealand continental waters in an environmentally responsible and sustainable manner; and
- Build effective working relationships between government, industry and research stakeholders.

Under the Code of Conduct, three levels of seismic survey are defined based on the power level of the acoustic array. Level 1 surveys (>427 in^3) are typically large-scale geophysical investigations, Level 2 surveys (151 – 426 in^3) are lower scale seismic investigations often associated with scientific research, and Level 3 surveys (<150 in^3) include all small-scale, low-impact surveys. The combined output of the source array to be utilised for the checkout surveys (i.e. 450 in^3) means the Taranaki Checkshot Surveys are classified as Level 1 surveys. The Code of Conduct requirements for a Level 1 seismic survey are provided below.

3.5.1 Notification

Under the Code of Conduct, an operator may not carry out a marine seismic survey unless they have notified the Director-General of Conservation in writing at least three months prior to the commencement of the survey.

OMV notified the Director General of Conservation on 26 June 2019 of its intention to undertake checkshot surveys as part of the wider Taranaki and Māui EAD Programmes.

3.5.2 Marine Mammal Impact Assessment

To comply with the Code of Conduct, a MMIA is required to:

- Describe the activities related to the survey;
- Describe the state of the local environment in relation to marine species and habitats, with a particular focus on marine mammals;

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

3.5.3 Areas of Ecological Importance

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

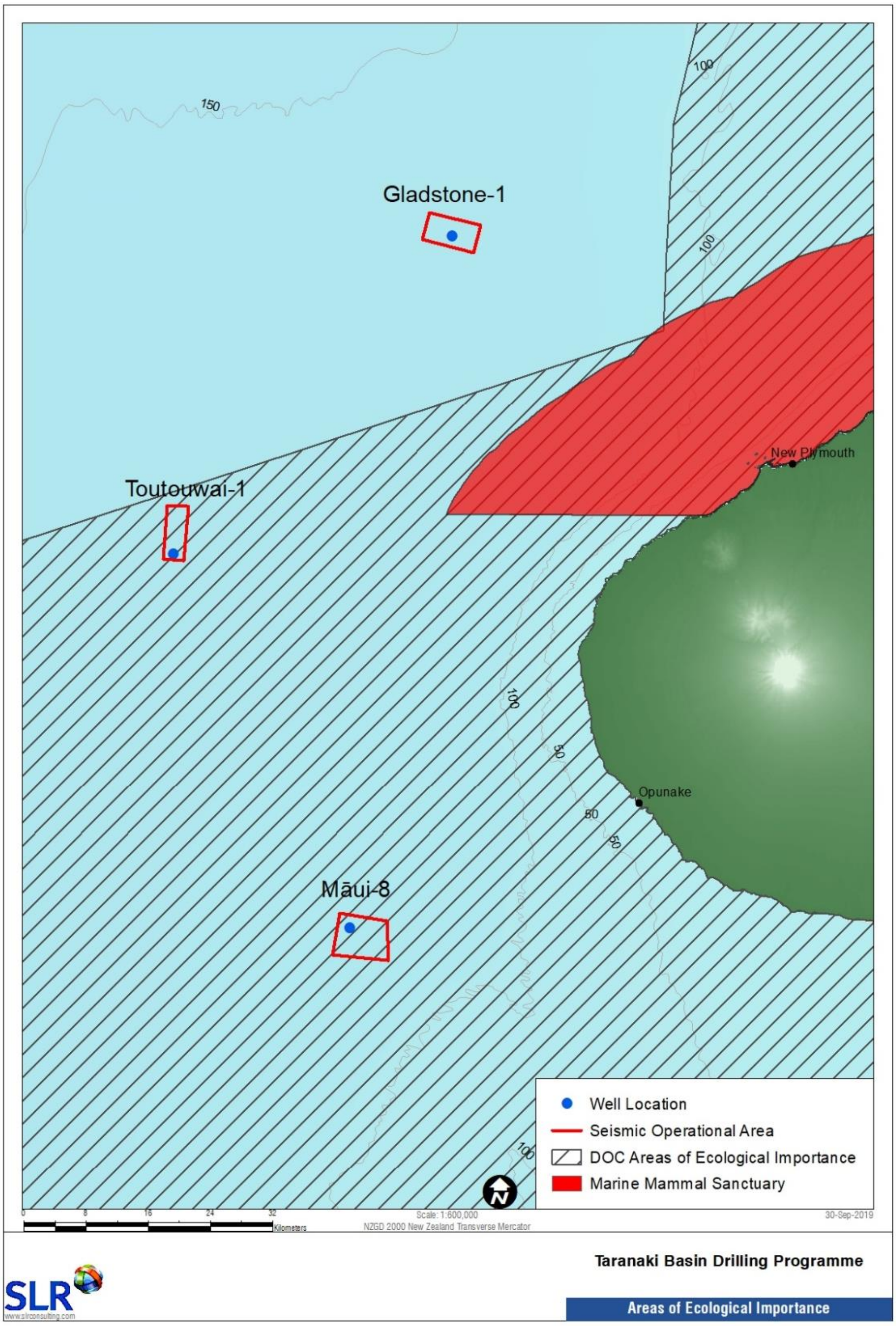
The extent of the Areas of Ecological Importance around New Zealand was determined from DOC's database of marine mammal sightings and strandings, fisheries-related data maintained by the Ministry for Primary Industries, and the National Aquatic Biodiversity Information System. Where data was incomplete or absent, technical experts have helped refine the Area of Ecological Importance maps. The Taranaki Checkshot Surveys will largely occur within the Area of Ecological Importance (**Figure 4**).

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

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

If the STLM predicts exceedances of these thresholds at any of the Operational Area locations, then consideration must be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. Although the Gladstone-1 Operational Area does not lie within the Area of Ecological Importance, OMV has undertaken STLM for each of the initial three well locations to be drilled in the Taranaki and Māui EAD Programmes (**Appendix A**). Results from the STLM undertaken at each well location are discussed in **Section 6.2.2.1**.

Figure 4 Relationship between the Operational Areas and Areas of Ecological Importance



3.5.4 Observer Requirements

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

To undertake a Level 1 seismic survey in compliance with the Code of Conduct, the minimum qualified observer requirements are:

- There will be at least two trained and qualified MMOs on-board at all times;
- There will be at least two trained and qualified PAM Operators on-board at all times to provide 24-hour coverage;
- 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.

Note that in the event that qualified MMO and PAM Operator personnel are unable to be engaged for the Taranaki Checkshot Surveys, the Code of Conduct provides for a qualified MMO or PAM Operator to act as a supervisor/mentor to a trained MMO or PAM Operator. Therefore, one qualified observer and one trained observed may be engaged in each observation role (i.e. MMO or PAM Operator); however, at least one of the engaged MMOs will be qualified as there are no provisions under the Code of Conduct for a suitable trained MMO to undertake the same role as a qualified MMO. Given the unknowns around the duration and timing of the Taranaki and Māui EAD Programmes and associated checkshot surveys, details of the observers engaged for the Taranaki Checkshot Surveys are not known as part of this MMIA process. Prior to the commencement of the Taranaki Checkshot Surveys, the names, qualifications, and experience of each observer will be provided to DOC and the EPA for approval/acceptance.

If observers (i.e. MMOs or PAM Operators) consider that there are higher than expected numbers of marine mammals encountered during seismic survey operations, they are required to immediately notify the Director-General of Conservation. If this occurred, adaptive management procedures will be agreed following a discussion between DOC and OMV. In the event that the Director-General determines additional measures are necessary, the MMO/PAM team in conjunction with OMV would then immediately implement any adaptive management actions without delay.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans (i.e. Hector's/Māui's dolphin, dwarf sperm whale, and spectacled porpoise), any such detection will require an immediate shutdown of an active source or will delay the start of operations, regardless of signal strength or whether distance or bearing from the acoustic source has been determined. It is not necessary to determine whether the marine mammal is within a mitigation zone. However, shutdown of an activated source will not be required if visual observations by 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.

OMV has contracted Blue Planet Marine to provide the required MMOs and PAM Operators for any checkshot surveys that may be conducted in the initial three wells in the Taranaki and Māui EAD Programmes. Blue Planet Marine personnel and their equipment will be located onboard the MODU, and on the support vessel where the PAM system will be deployed. The MMOs and PAM Operators will be qualified and trained in accordance with the Code of Conduct and will be in close contact with each other, even though they are on different vessels.

MMO observations can only be made during daylight hours whereas PAM can be operational on a 24-hour basis. Details of the PAM specifications are provided in **Appendix B**.

3.5.5 Operational and Reporting Requirements

MMOs and PAM Operators are required under the Code of Conduct to record and report all marine mammal sightings during the survey. All raw datasheets must be submitted directly to DOC by the qualified no longer than 14 days after the completion of checkshot survey. A written final trip report must also be provided to DOC at the earliest opportunity, but no later than 60 days after the completion of the project. The operational duties of MMOs and PAM Operators during seismic operations are outlined in **Table 4**.

Table 4 Operational Duties of MMOs and PAM Operators

Operational Duties	
MMO Duties	**PAM Operator Duties**
Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.	Provide effective briefings to crew members, and establish clear lines of communication and procedures for on-board operations.
Continually scan the water surface in all directions around the acoustic source for presence of marine mammals, using a combination of naked eye and high-quality binoculars from optimum vantage points for unimpaired visual observations.	Deploy, retrieve, test and optimise hydrophone arrays.
Determine distance/bearing and plot positions of marine mammals whenever possible during sightings using GPS, sextant, reticule binoculars, compass, measuring sticks, angle boards or other appropriate tools.	When on duty, concentrate on continually listening to received signals and/or monitor PAM display screens in order to detect vocalising cetaceans, except when required to attend to PAM equipment.

Record/report all marine mammal sightings, including species, group size, behaviour/activity, presence of calves, distance and direction of travel (if discernible).	Use appropriate sample analysis and filtering techniques.
Record sighting conditions (Beaufort sea state, swell height, visibility, fog/rain and glare) at the beginning and end of the observation period, and when there is a significant change in weather condition.	Record and report all cetacean detections, including - if discernible - identification of species or cetacean group, position, distance and bearing from vessel and acoustic source. Record the type and nature of sound, and the time and duration it was heard.
Implement appropriate mitigation actions (delayed starts and shut downs).	Implement appropriate mitigation actions (delayed starts and shut downs).
Record acoustic source power output while in operation, and any mitigation measure taken.	Record general environmental conditions, acoustic source power output while in operation, and any mitigation measures taken.
Communicate with DOC to clarify any uncertainty or ambiguity in application of the Code of Conduct.	Communicate with DOC to clarify any uncertainty or ambiguity in application of the Code of Conduct.
Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct.	Immediately report to DOC and the EPA any instances of non-compliance with the Code of Conduct.

3.5.6 Pre-start Observations

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

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

The Code of Conduct provides additional observation requirements for surveys starting up at a 'new location'. For the Taranaki Checkshot Surveys the acoustic source will be deployed from the stationary MODU and will therefore remain in one location over the entire survey. However, activation of the acoustic source for each new survey (i.e. at Gladstone-1, Toutouwai-1, and Māui-8) meets the definition of a new location, therefore the following additional requirements for start-up at night or in poor sightings conditions will be applied:

- MMOs will have undertaken observations within 20 NM of the planned start-up position for at least the last two hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or

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

3.5.7 Soft Starts

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

The acoustic source will not be activated at any time except by soft start, unless the source is being reactivated after a single break in firing (not in response to a marine mammal observation within a mitigation zone) of less than 10 minutes immediately following normal operations at full power, and the qualified observers have not detected marine mammals in the relevant mitigation zones. Activation of the acoustic source at least once within sequential 10-minute periods shall be regarded as continuous operation.

3.5.8 Delayed Starts and Shutdowns

The following Code of Conduct requirements for delayed starts and shutdowns will be followed. Stricter mitigation measures have been implemented for marine mammals classified as a 'Species of Concern' (i.e. all whales and most dolphins in New Zealand) under Schedule 2 of the Code of Conduct. Species of Concern are identified in **Table 12**, with the full list provided as **Appendix C**. Marine mammals not considered a 'Species of Concern' fall under the category of 'Other Marine Mammal'.

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

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

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

3.5.8.2 Species of Concern within a Mitigation Zone of 1 km

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

- A qualified observer confirms the Species of Concern has moved to a point that is more than 1 km from the acoustic source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a Species of Concern within 1 km of the acoustic source, and the mitigation zone remains clear.

3.5.8.3 Other Marine Mammals within a Mitigation Zone of 200 m

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

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

Once all marine mammals that were detected within the relevant mitigation zones have been observed to have moved beyond the respective mitigation zones, and the mitigation zone has remained clear for 30 minutes, there will be no further delays to the initiation of soft start procedures.

4 Stakeholder Engagement

The checkshot surveys that may be acquired at Gladstone-1 and Toutouwai-1 are part of the Taranaki EAD Programme, while the checkshot survey at Māui-8 is a component of the Māui EAD Programme. As such, engagement for these checkshot surveys has been undertaken as part of the engagement programmes for the Taranaki and Māui EAD Programmes respectively.

Throughout the Taranaki and Māui EAD Programmes, OMV has undertaken an engagement process that has involved a wide number of groups, including iwi and hapū groups, fishing interests, regional councils, government departments, and any other groups identified as being interested parties or having an existing interest.

In addition to the consultation that has been undertaken for the Taranaki and Māui EAD Programmes, consultation has been undertaken for a very long time in relation to activities at the Māui Field. Prior to 2018, Māui Field consultation was undertaken by Shell, and this consistency has remained with the Shell staff now working for OMV. This historical engagement has covered a range of topics, including the PML, activity planning, overview of the oil and gas industry, seismic data acquisition, exploration, development and production drilling.

In addition to the prior consultation, OMV undertakes an ongoing engagement programme by convening a Community Advisory Group that meets at least quarterly with representatives from iwi and hapū groups, along with other relevant stakeholders. The purpose of this Community Advisory Group is to provide these groups with information about the EAD Programmes (including the timing of activities and monitoring results), along with providing a forum for those parties to ask questions and provide feedback to OMV on issues relating to the EAD Programmes. This ongoing consultation will promote shared understandings between the stakeholders and OMV of their respective cultural, environmental, social and economic objectives in the context of the activities within the EAD Programmes.

In the period between quarterly EAD Community Advisory Group meetings, OMV meets informally once per month with each EAD Community Advisory Group member to provide updated, ensure that information is reaching the appropriate persons, answer questions, and to discuss the process and effectiveness of the EAD Community Advisory Group. These informal meetings are especially valuable, as individual Community Advisory Group participants are more open with their feedback in a one-on-one situation than they tend to be in a formal multi-participant meeting.

Table 5 provides a list of the groups that OMV has engaged with as part of the Taranaki and Māui EAD Programmes. Based on the confined spatial extent of predicted effects from the Taranaki Checkshot Surveys, as confirmed by the STLM (**Appendix A**) the engagement process has been limited and targeted towards certain key stakeholder groups.

OMV has not received any feedback or concerns regarding the Taranaki Checkshot Surveys throughout the extensive consultation process with iwi and stakeholders.

Table 5 Stakeholders and iwi groups OMV has Engaged with

Regulators and DOC
EPA
DOC – Taranaki
DOC – National Office
Regional Council
Taranaki Regional Council
Iwi and Hapū
Ngati Tama
Ngati Mutunga
Te Kāhui o Taranaki
Te Kotahitanga o Te Atiawa - Manukorihi hapū, Otaraoa hapū, Ngati Rahiri hapū, Puketapu hapū, Tawhirikura hapū
Te Korowai o Ngaruahine Trust
Ngati Ruanui
Te Kaahui o Nga Rauru
Fisheries Groups
Te Ohu Kaimoana
Deepwater Fisheries Group

5 Existing Environment

5.1 Physical Environment

5.1.1 Meteorology

The climate of New Zealand varies from warm subtropical in the upper north to cool temperate in the lower south (NIWA, 2019). Anticyclones are a major feature as they migrate eastwards across the country every six to seven days. Overall, anticyclones follow northerly paths in the spring and southerly paths in the autumn and winter. As each anticyclone moves off the east coast, north-westerly winds bring a cold front across the country. Cold fronts are followed by troughs of low pressure characterised by increased cloud cover, intensifying north-westerly winds and precipitation that persists until the front passes eastward (Te Ara, 2019). After the front has passed, the weather conditions change again to cold showery south-westerly winds, before the arrival of the next anticyclone.

The Operational Areas are located in the 'South-west North Island' climate zone, which is windy relative to other regions with few climatic extremes (NIWA, 2019a). Taranaki is considered one of the windiest regions in New Zealand (Chappell, 2014). Within this climatic zone the most settled weather occurs in summer and early autumn, with winter months the most unsettled time of the year (NIWA, 2019a).

A summary of the wind statistics found at the three Operational Areas is shown in **Table 6**.

Table 6 Summary of Wind Statistics for Representative Sites in the Operational Areas

Metocean modelling target area	Distance from Checkshot Operational Area	Average wind speed (m/s) [1]	Maximum wind speed (m/s) [2]	Dominant wind directions	Seasonal trends
North Taranaki exploration area (MOS, 2018)	24 km WNW of Gladstone-1 Operational Area	7.9	22.2	Southwest and west	Generally southwest and west all year, with some north-westerlies during spring.
Tui Development Area (MOS, 2006)	30 km SE of Toutouwai-1 Operational Area	8.5	24.3	Westerly quarter & southeast	West-southwest dominant spring and summer, with south-easterlies more prevalent in autumn and winter.
Māui Platform B (Garvey, 2017)	9 km SW of Māui-8 Operational Area	Not provided	24.7	Westerly quarter & southeast	West to west-southwest and southeast dominates all year, with south-easterlies in summer, autumn and winter.

1. Modelled omnidirectional 10-minute mean
2. Modelled omnidirectional 10-minute maximum (1-year return period)

Periods of high rainfall occur in Taranaki when a slow-moving anticyclone lies to the east of New Zealand, allowing warmer moist northerly air from the tropics to flow over the country. Heavy rain can occur if these conditions are associated with slow-moving fronts lying north-south near Taranaki, or when depressions move across the region. When the airflow over New Zealand is from the northeast, rainfall in Taranaki tends to be scattered and light until the next frontal zone crosses the region. In Taranaki, westerly airstreams are associated with periods of unsettled showery weather. In these situations, a belt of high pressure lies to the north of the country, while to the south migratory depressions move steadily eastwards. The westerly airstream frequently contains rapidly moving cold fronts bringing periods of heavier showers to western New Zealand. Rain frequency and intensity increases inland towards Mount Egmont/Taranaki (Chappell, 2014).

5.1.2 Currents and Waves

5.1.2.1 Currents

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

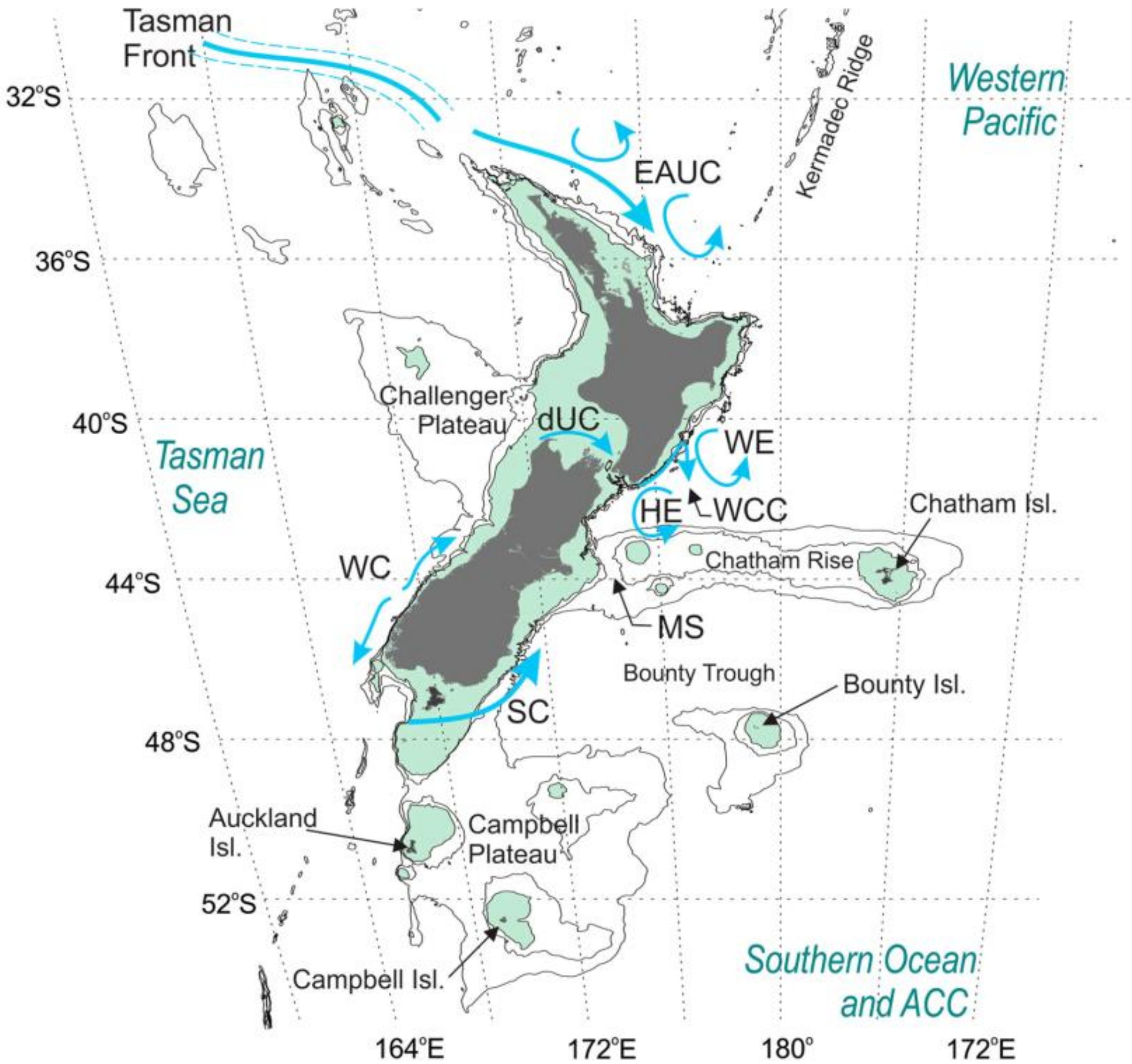
New Zealand lies in the pathway of eastward-flowing currents driven by winds that blow across the South Pacific Ocean (Brodie, 1960; Te Ara, 2019a). As a result, New Zealand is exposed to the southern branch of the South Pacific subtropical gyre driven by the southeast trade winds to the north and the Roaring Forties westerly winds to the south (Gorman *et al.*, 2005; Te Ara, 2019a).

The main ocean currents around New Zealand are illustrated in **Figure 5**. The eastward flow out of the Tasman Sea splits into two currents across the top of the North Island: the West Auckland Current flowing from Cape Reinga towards Kaipara, and the East Auckland Current flowing from North Cape towards the Bay of Plenty (Brodie, 1960; Heath, 1985; Stanton, 1973). As the West Auckland Current travels south, it is met in the North Taranaki Bight by the north-flowing Westland Current. The Westland Current flows from the west coast of the South Island up to the west coast of the North Island where it weakens and becomes subject to seasonal variability. As a result of local weather conditions and seasonality, the convergence zone of the two currents is highly variable (Brodie, 1960; Ridgway, 1980; Stanton, 1973).

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

Currents that traverse across the Operational Areas are predominantly influenced by the D'Urville and Westland Currents in the south, and the West Auckland Current in the north. Tidal currents on the Continental Shelf around Taranaki have been reported at speeds of approximately 0.07 m/s, with internal tides generating currents up to 0.3 m/s along the shelf edge (Orpin, 2015).

Figure 5 Ocean Circulation around the New Zealand Coastline



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

Source: Stevens *et al.,* 2019

5.1.2.2 Waves

The Taranaki Bight is considered to have a high-energy wave climate due to its exposure to long-period swells originating from the Southern Ocean and locally generated seas (Hume, *et al.*, 2015). The majority of the wave energy arrives from the west and southwest, with southerly waves able to rapidly rise. In general, wave height in the Taranaki Bight shows a seasonal cycle, with mean significant wave heights peaking in late winter and lowest in late summer (MacDiarmid *et al.*, 2015), although large-wave conditions can arise at any time of the year; significant wave heights in excess of 8 m can occur during stormy conditions, particularly in the winter and early spring (MacDiarmid *et al.*, 2015). The largest waves are found off the western end of Cape Egmont, with wave height decreasing further south as a result of the north-western tip of the South Island providing shelter from the prevailing south-westerly swells (MacDiarmid *et al.*, 2015).

Wave modelling (**Table 7**) shows an average annual significant wave height of 2.8 - 2.9 m for the three Operational Areas, with a maximum annual significant wave height of 8.5 - 10.5 m (MOS, 2018; MOS, 2006; Garvey, 2017).

Table 7 Wave Statistics for the Operational Areas

Metocean modelling target area	Distance from Checkshot Operational Areas	Average annual wave height (m)	Maximum annual wave height (m)	Dominant swell directions
North Taranaki exploration area (MOS, 2018)	24 km WNW of Gladstone-1 Operational Area	2.8	10.5	Southwest
Tui Development Area (MOS, 2006)	30 km SE of Toutouwai-1 Operational Area	2.9	8.5	Southwest and west
Māui Platform B (Garvey, 2017)	9 km SW of Māui-8 Operational Area	Not provided	9.9	West-southwest

5.1.3 Thermoclines and Sea Surface Temperature

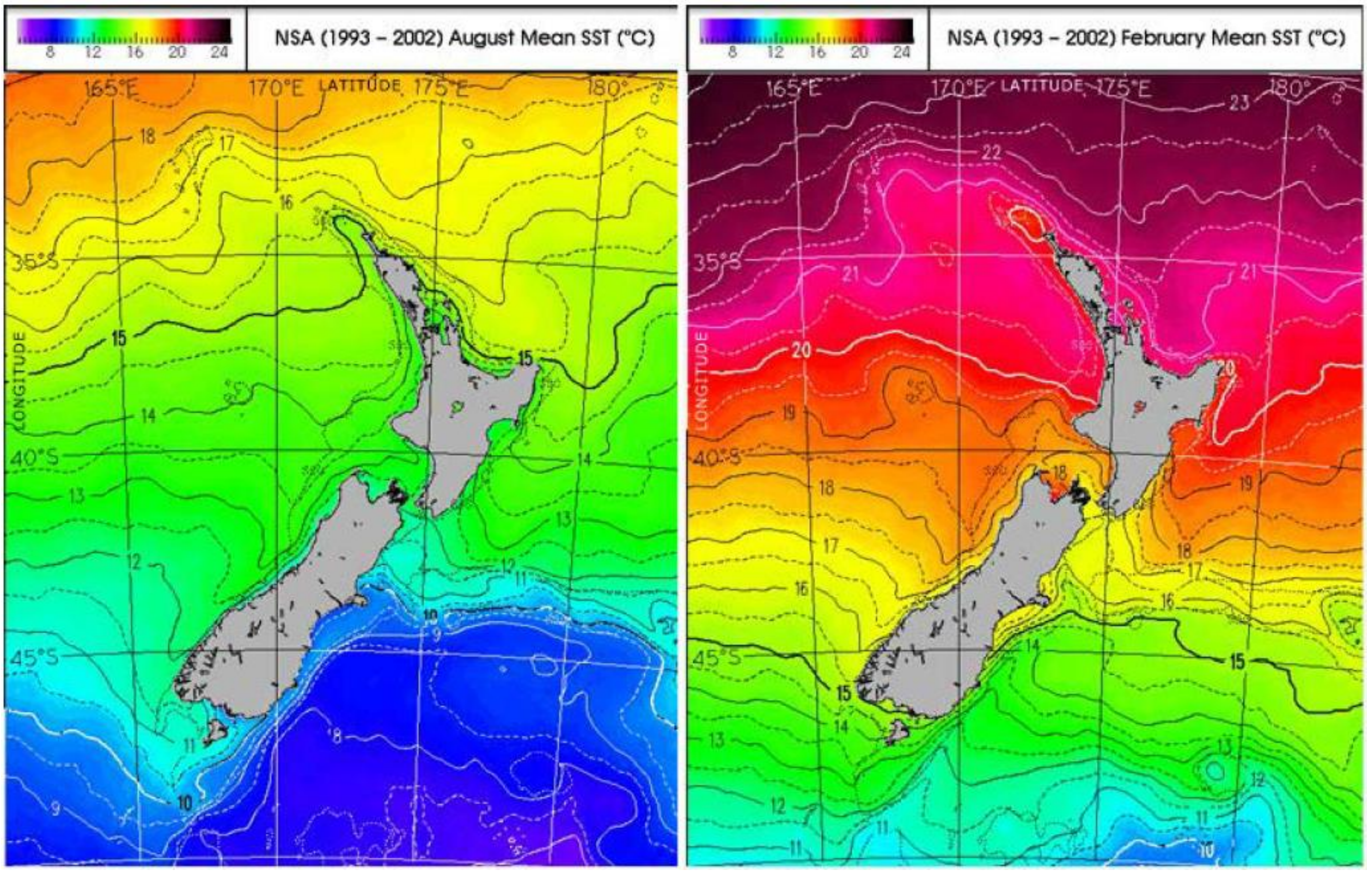
Sea surface temperatures in New Zealand waters generally show a north-to-south gradient, with warmer waters being found in the north, cooling towards the south (Te Ara, 2019b).

The National Institute of Water and Atmospheric Research (**NIWA**) produced sea surface temperature maps using data extracted from daily NOAA satellite transmissions (from 1993 - 2002). According to this, sea surface temperatures in the Taranaki Bight are approximately 13 – 14 °C in winter (August), and 18 – 20 °C in summer (February) (**Figure 6**) (Te Ara, 2019b).

Thermal stratification of the water column can develop during summer months as a result of solar heating across the water surface. The thermocline profile varies depending on the sea state conditions which determine the degree of vertical mixing and consequent breakdown of the thermal structure. Tides and currents can also either enhance or damage the structure of the thermocline, therefore a well-defined thermocline is not always present (ASR, 2003). Below the thermocline, water temperature typically falls rapidly along a vertical gradient (Garner, 1969).

Metocean modelling estimates the spring/summer thermocline mixing layer to exist at depths of approximately 30 – 50 m, on average, below which the temperature gradually drops (MOS, 2006; MOS, 2018).

Figure 6 Average New Zealand Sea Surface Temperature for Winter (left) and Summer (right)



Source: Te Ara, 2019b

5.1.4 Ambient Noise

Hildebrand (2009) defines ambient noise in the ocean as the sound field against which signals must be detected. In the marine environment, ambient noise is generated by numerous sources, including:

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

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

In 2016, NIWA deployed seven passive acoustic monitoring devices on moorings in the greater Cook Strait region. While the intention of the deployments was to gather baseline ambient noise conditions and to better understand the spatial distribution, habitat use, calling behaviour and migration of marine mammals in this region, results from the study provide an indication of the marine soundscape in the vicinity of the Operational Areas.

NIWA's closest monitoring location to the Operational Areas was off the Manawatu/Kapiti coastline, where the mooring was deployed from June 2016 to August 2017. A presentation given at the New Zealand Petroleum Conference showed the ambient noise levels ranged from 150 – 180 dB re 1 $\mu Pa^2.s$ (Giorli *et al.*, 2018). However, these ambient noise levels incorporated vessel noise and the presence of a seismic survey during the deployment.

Vessel noise was found to be the dominant contributor to the shallow water soundscape (i.e. < 250 m) while deeper water environments had a number of different noise sources (i.e. vessels, seismic surveys, marine mammals and earthquakes) (Giorli *et al*., 2018).

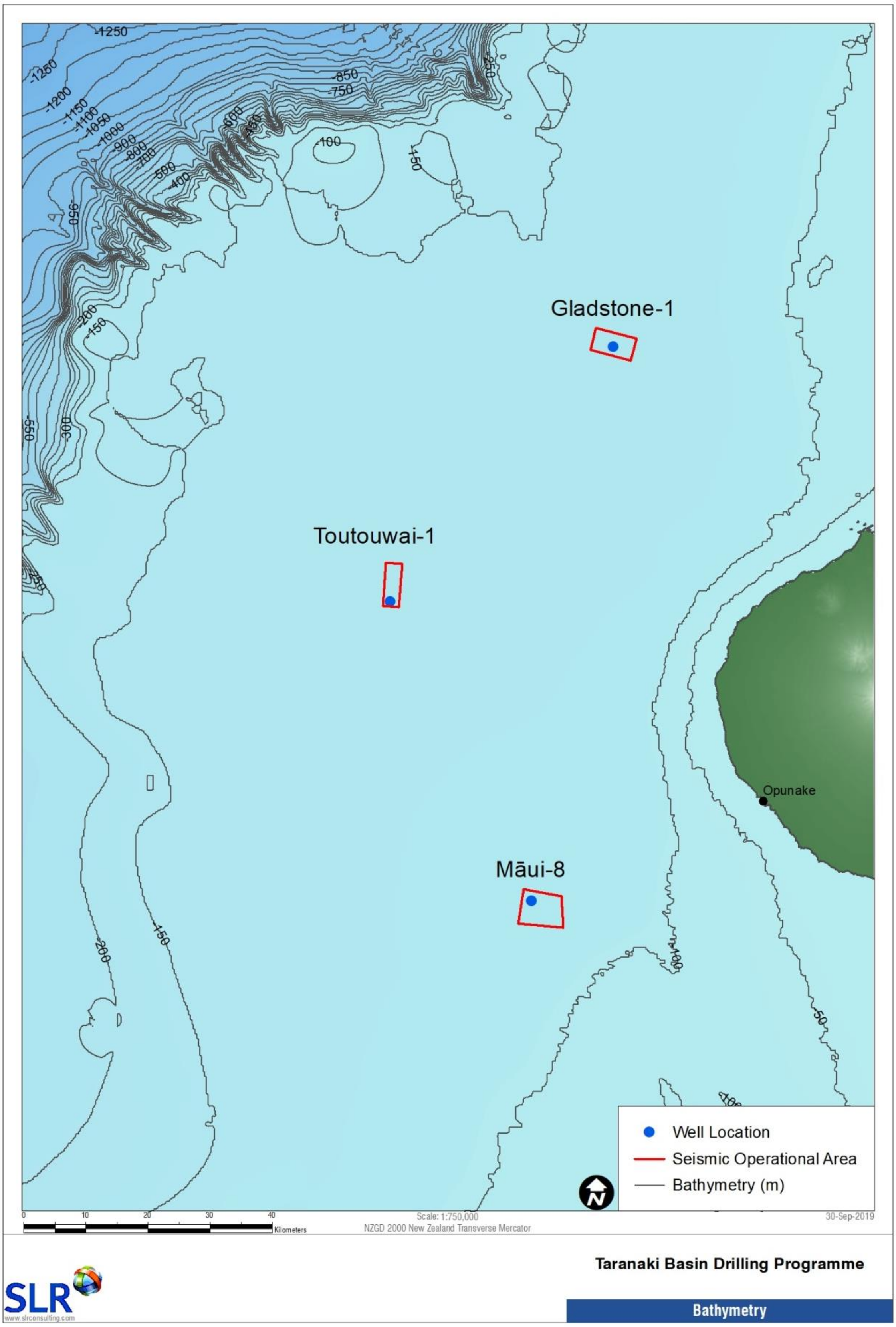
5.1.5 Bathymetry and Geology

New Zealand is surrounded by a gently sloping continental shelf, extending from the coast out to a water depth of 100 – 160 m. Beyond this, the gradient of the seabed steepens as the sea floor transitions into the continental slope. The continental slope descends relatively rapidly from the edge of the shelf down to depths of more than 4,000 m. At the foot of the slope, the seaward gradient flattens out into ocean basins – wide, undulating but relatively flat zones lying at depths of 4,000 – 5,000 m (Te Ara, 2019c).

The surface of the continental shelf is predominantly flat although punctuated by local banks and reefs, whereas the slope is irregular with large marine valleys called submarine canyons. These canyons occur where the slope is relatively steep (e.g. off Kaikoura) and generally run from the edge of the continental shelf to the foot of the continental slope (Te Ara, 2019c). There are no submarine canyons located near the Operational Areas.

The width of New Zealand's continental shelf varies. In the North Taranaki Bight the shelf is broad, narrowing around Cape Egmont before widening again across the South Taranaki Bight (MacDiarmid *et al.*, 2015) (**Figure 7**). The Taranaki continental shelf has a 150 km wide opening to the Tasman Sea, occupying approximately 30,000 km^2, and slopes gently towards the west with an overall gradient of <0.1° (up to 0.5° locally) (Nodder, 1995).

Figure 7 Seabed Bathymetry of the Operational Areas



There are eight sedimentary basins underlying New Zealand's continental shelf with known or potential hydrocarbons present (**Figure 8**). To date, commercial quantities of oil and gas have only been produced from the Taranaki Basin; however, non-commercial hydrocarbon discoveries have been made in the East Coast, Canterbury and Great South basins (NZP&M, 2014).

The Operational Areas are located within the Taranaki Basin, which lies at the southern end of a rift that developed sub-parallel to the Tasman Sea rift that now separates Australia from New Zealand. The Taranaki Basin occupies the site of a late Mesozoic extension on the landward side of the Gondwana margin and covers approximately 330,000 km^2. The current structure of the basin is controlled by movements along the Taranaki, Cape Egmont and Turi fault zones (NZP&M, 2014).

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

Figure 8 New Zealand's Sedimentary Basins

Source: NZP&M, 2014

5.2 Biological Environment

5.2.1 New Zealand Marine Environment Classification

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

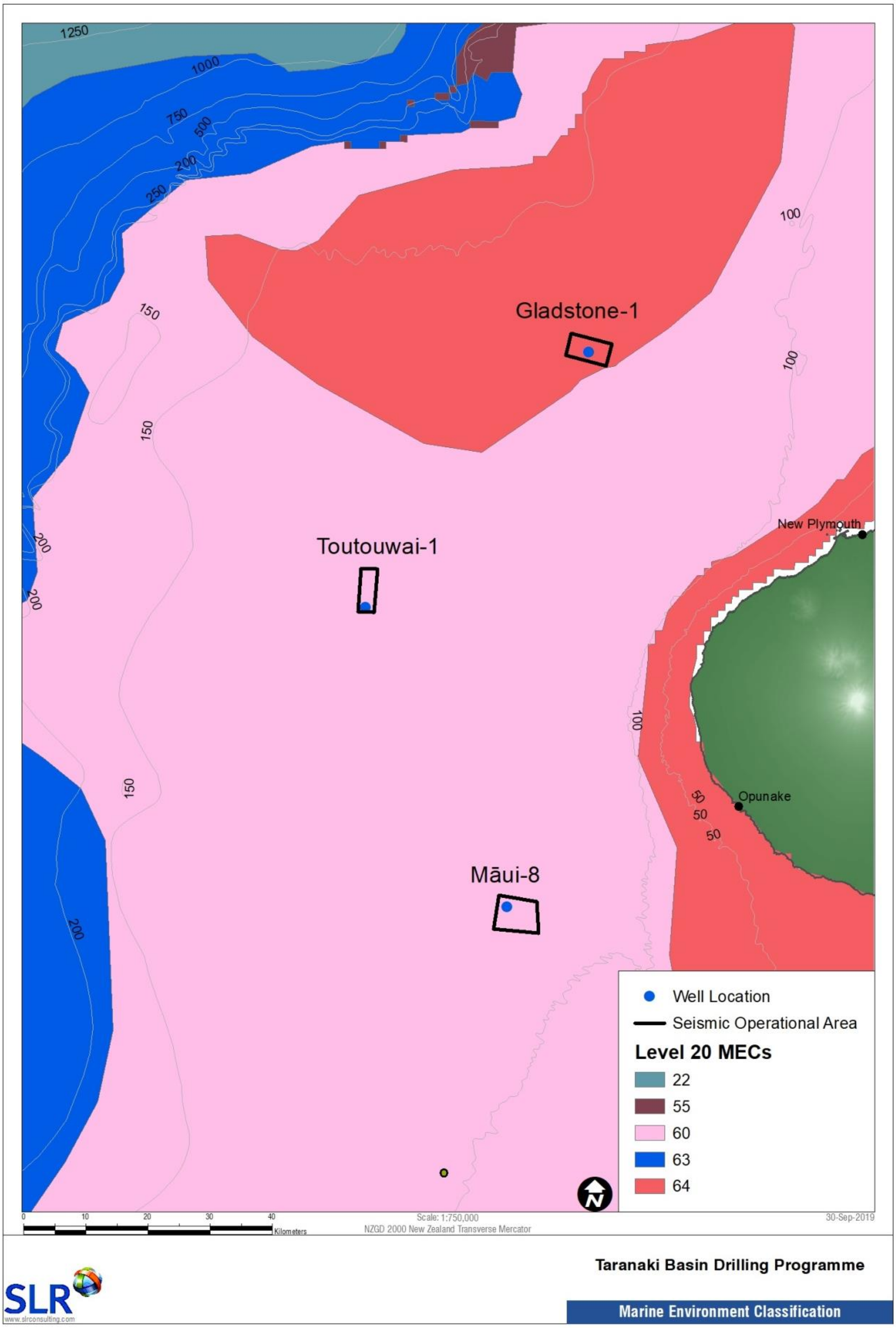
According to this classification, the Gladstone-1 Operational Area consists of Class 64 characteristics, while the Toutouwai-1 and Māui-8 Operational Areas consist of Class 60 characteristics (**Figure 9**). These classifications are also useful in providing a general understanding of what marine species could be present within the Operational Areas, specifically when data is limited. These classes are described in further detail below, following the definitions by NIWA (Snelder *et al.*, 2005).

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

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

It is worth noting that although the Gladstone-1 Operational Area has been classified by Snelder *et al*. (2005) as being within Class 64, this area is believed to more akin to Class 60 as per the surrounding area. Class 64 identifies more coastal areas, with shallow water (mean of 38 m); whereas the wells that are located in this area are in depths ranging from 131 m to 146 m. Therefore, although a discussion is included above around Class 64 for completeness, the Gladstone-1 Operational Area is considered to more appropriately fall within Class 60.

Figure 9 New Zealand Marine Environmental Classifications around the Operational Areas



5.2.2 Plankton

Plankton are drifting plants or animals that inhabit the pelagic zone of the world's oceans. These organisms fulfil the primary producer role in the ocean and form the basis of the marine food web. Plankton have limited swimming ability and float passively with the ocean currents, which primarily controls their horizontal distribution. Some plankton can however move vertically within the water column. Plankton can be classified into four broad functional groups:

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

Oceanic productivity is influenced by many factors, such as currents, climate and bathymetry, which cause upwelling and create nutrient-rich waters. Such conditions are ideal for the growth of plankton and plankton-consuming animals (MacKenzie, 2014). The semi-enclosed area of the South Taranaki Bight and Western Cook Strait is impacted by several large-scale physical phenomena (e.g. the Kahurangi upwelling, tidal mixing, and river plumes) which structure the distribution and biomass of plankton. Bradford and Roberts (1978) suggested that the 'Taranaki Bight and wider Cook Strait region' is one of only four coastal regions around New Zealand in which zooplankton biomass exceeds 300 mg m^{-3} making it an area of enhanced productivity.

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

Oceanic productivity also varies seasonally; in summer, stratification occurs in the water column (due to a lack of mixing) and as such, phytoplankton are able to remain at the sea surface and continuously photosynthesise throughout daylight hours. However, in the process of photosynthesising, the phytoplankton use up available nutrients in the surrounding water, resulting in a decline in primary productivity. Phytoplankton biomass also declines with the increase in grazing zooplankton.

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

The most thorough assessment of zooplankton assemblages off the west coast of the North and South Islands was carried out by Bradford-Grieve *et al*. (1993) who studied the structure of the zooplankton communities within the Kahurangi Upwelling and Greater Cook Strait (within the South Taranaki Bight, bound by a line between Cape Egmont and Cape Farewell). This assessment is most relevant to the Toutouwai-1 and Māui-8 Operational Areas. Bradford-Grieve *et al*. (1993) summarised the Greater Cook Strait zooplankton assemblages into five geographic groupings. These groupings generally reflected the position relative to upwelling pulses.

The results showed that, near the source of the upwelling plume:

- Inshore zooplankton biomass and the abundances of several coastal species decreased;
- Oceanic species were introduced into nearshore water;
- Copepods and the euphausiid *Nyctiphanes australis* showed reduced reproduction; and
- The diversity indices and proportion of herbivorous copepods decreased, relative to water south of the plume.

Downstream from the plume source, in the eastern part of the upwelling plume, the results showed that:

- Many zooplankton species were distributed in a manner reflecting the physical characteristics of the plume, whereas oceanic forms were entrained along the offshore border of the plume;
- The proportion of omnivorous copepods was reduced and the capacity of herbivorous copepods and *Nyctiphanes australis* to reproduce increased; and
- The abundance of selected coastal copepods was apparently related to their vulnerability to offshore transport on an upwelling coast.

Other zooplankton studies relevant to the Operational Areas and surrounding areas include Foster and Battaerd (1985) who conducted zooplankton tows across the South Taranaki Bight and Cape Farewell as far north as approximately the Tui Field (near Toutouwai-1). This study found that the zooplankton present were mostly neritic species and that there was an increase in the abundance of copepod nauplii 'down-stream' of the Kahurangi Upwelling indicating the start of a zooplankton response to enhanced grazing conditions.

James and Wilkinson (1988) investigated the zooplankton assemblages from Cape Farewell and the South Taranaki Bight during voyages from March to April. The authors reported a peak in biomass associated with the Kahurangi Upwelling. The small copepod *Acartia ensifera* dominated (20 – 60%) the biomass throughout the South Taranaki Bight, with *Centropages aucklandicus* and *Paracalanus indicus* accounting for the remainder. *N. australis* commonly contributed 50 – 60% of the dry weight towards the eastern portion of the South Taranaki Bight (James & Wilkinson, 1988).

More recently, MacDiarmid *et al.* (2015) sampled zooplankton communities in the South Taranaki Bight and the results were in agreement with the findings of James and Wilkinson (1988), Foster and Battaerd (1985), and Bradford-Grieve *et al.* (1993).

The zooplankton communities present within the Māui-8 Operational Area are expected to be similar to those reported by Bradford-Grieve *et al.*, (1993) and MacDiarmid *et al.* (2015a). The Gladstone-1 and Toutouwai-1 Operational Areas are situated further north and there have been no detailed investigations into the zooplankton communities in these areas. However, Bradford-Grieve *et al.* (1993) reported that zooplankton biomass is greatest at mid-shelf locations near the coldest water at the Kahurangi Upwelling, with biomass decreasing immediately downstream of the upwelling. As such, it is expected that the zooplankton communities at Gladstone-1 and Toutouwai-1 will be less diverse and of lower biomass than those at Māui-8, which is influenced by the Kahurangi Upwelling.

5.2.3 Invertebrates

As part of the Taranaki EAD Programme, benthic baseline surveys were carried out at the proposed Gladstone-1 and Toutouwai-1 sites (as well as at a number of other potential well locations) in March – April 2018 to gain an understanding of the benthic habitat and communities. Similarly, the Māui Field EAD Benthic Baseline Survey was undertaken in November 2018 in the area encompassing Māui-8.

Benthic sediment samples were collected using a double Van Veen grab sampler. Single representative grabs were collected at 15 benthic monitoring stations surrounding each well site; with station locations laid out along the major and minor predicted axes of deposition should a well be drilled at that location. The entire sample for infauna analysis (approximately 11 L of sediment) is washed over 0.5 mm mesh until approximately 300 – 500 ml of residual sediment and organisms remains. This remaining material is then preserved with a fixative and taken to the taxonomy laboratory where taxonomists sort, identify and enumerate all organisms within the samples.

Video footage was captured by towing a video sled through ten stations around each well site using a customised tow-sled fitted with high-intensity LED lighting and a high-definition video camera.

Table 8 shows the findings of the benthic invertebrates from the benthic baseline surveys at the Gladstone-1, Toutouwai-1 and Māui-8 sites and further results at each site are presented in the sub-sections below. No benthic species considered to be ‘at risk’ or ‘threatened’ (under the New Zealand Threat Classification System) have been found in offshore Taranaki waters (MacDiarmid et al., 2015).

Table 8 Univariate Results for Benthic Invertebrates from the Benthic Baseline Monitoring Programmes at Gladstone-1, Toutouwai-1, and the Māui Field

Site	Number of Samples	Mean Number of Taxa	Mean Abundance	Total Number of Taxa Identified at Site	Total Number of Individuals (Abundance)
Gladstone-1	15	45	132	128	1,987
Toutouwai-1	15	31	68	90	1,023
Māui Field	45	44	170	130	7,658

5.2.3.1 Gladstone-1 Benthic Invertebrates

Infauna communities at the Gladstone-1 site were dominated by small polychaete worms (1,095 individuals (55%), 49 taxa), crustaceans (518 individuals (26%), 34 taxa, mostly ostracoda, amphipoda, and isopoda), and molluscs (171 individuals (9%), 27 taxa, mostly scaphopoda and small bivalvia).

Throughout the samples, two isolated Chaetopteridae worms (*Phyllochaetopterus socialis*) and one sea pen (*Virgulana gracillima*) were found; these are species defined in the Permitted Activities Regulations as being '*characteristic species of sensitive environments*'. Sea pens were also commonly observed in the video imagery collected at Gladstone-1; however, the occurrence and estimated densities of these taxa at Gladstone-1 during the benthic baseline survey did not reach the trigger levels defined by the Permitted Activities Regulations (MacDiarmid *et al.*, 2013), with no distinct fields of either taxa observed in the video imagery. Therefore, even those these species were present at the well locations in low densities, they were below the defined thresholds, and the area was not considered to be classified as a 'sensitive environment'.

5.2.3.2 Toutouwai-1 Benthic Invertebrates

Infauna communities at the Toutouwai-1 site were predominantly comprised of small polychaete worms (59%), crustaceans (23% - mainly ostracods, amphipods, isopods and cumaceans), and molluscs (11% - mostly bivalves and gastropods). No '*characteristic species of sensitive environments*' were found in the infauna samples, although video Imagery collected at Toutouwai-1 indicated the presence of sea pens (taxa defined as '*characteristic species of sensitive environments*'). However, estimated densities of sea pens did not reach the trigger levels defined by the Permitted Activities Regulations and no distinct sea pen 'fields' were encountered. Similarly, although seapens were present in low densities around the proposed Toutouwai-1 well location, the area was not classified as a sensitive environment.

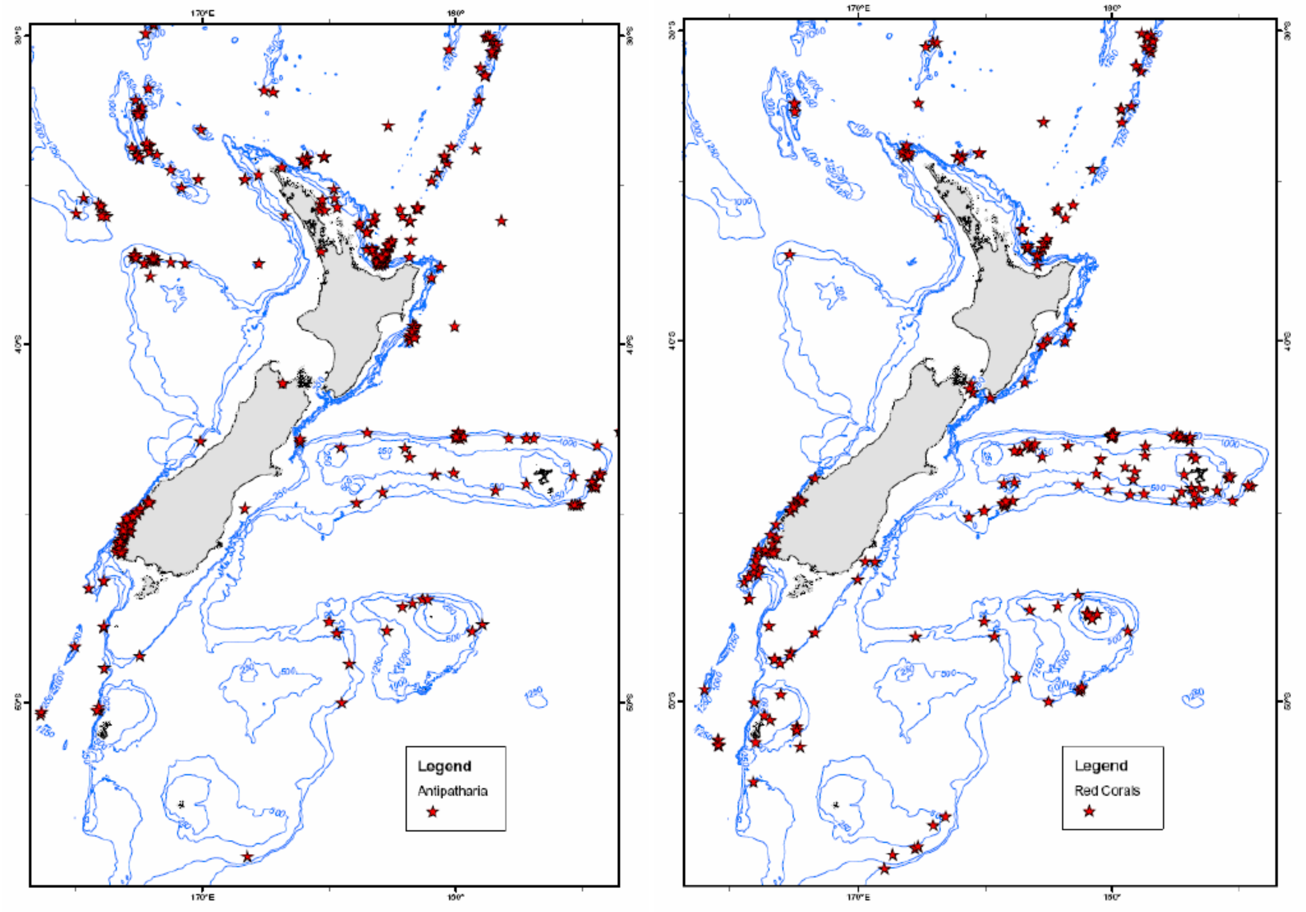
5.2.3.3 Māui Field (Māui-8, Māui South 2 and Nikau-1) Benthic Invertebrates

Infauna communities at the Māui Field were dominated by small polychaete worms (62%), bivalves (10%), gastropods (5%) and amphipods (5%). A single Chaetopteridae worm occurred in the 45 infauna samples collected, and there was no indication of any distinct worm-fields or low-relief worm meadows (characteristic of *P. socialis*) observed in the video imagery. Sea pens (*Virgularia gracillima*) were identified in two separate infauna samples but only one individual occurred in each of these samples. In the video imagery, sea pens were observed in low numbers across the entire surveyed area, with little variation in observed densities and no distinct sea pen 'fields' were encountered. The occurrence and estimated densities of both Chaetopteridae worms and sea pens did not reach the trigger levels for sensitive environments defined by the Permitted Activities Regulations.

5.2.3.4 Deepwater Corals

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). Deep-sea corals (such as black coral and stylasterid hydrocoral), are classified as protected species under the Wildlife Act 1953. Based on records from commercial fishing bycatch, NIWA have developed a database of coral distribution around New Zealand. The database identifies no significant densities of black coral or stylasterid coral in the Operational Areas (**Figure 10**). Hence corals are not considered further in this MMIA.

Figure 10 Distribution of Black Coral (Left) and Stylasterid Coral (Right)



Source: Consalvey *et al*. (2006)

5.2.4 Fish

The Operational Areas are located in the highly productive neritic zone of the ocean; the relatively shallow area that extends from the intertidal zone to the shelf break (approximately 200 m water depth). This zone supports commercially and recreationally important fish species that are generally highly mobile, do not have fixed territories, and often school (Roberts *et al.*, 2015).

Fish populations across the Operational Areas are represented by various demersal and pelagic species most of which have wide spatial distributions. The composition of the fish population in the Taranaki Bight is dynamic due to fish mobility and ecological and physical influences. For example, in summer, warmer currents move down from the north and larger pelagic species visit the waters of the Operational Areas. The most common of these seasonal species are sunfish, flying fish, marlin, albacore tuna, skipjack tuna, mako sharks and blue sharks.

Video sled imagery collected at previous exploration well sites, around existing offshore oil and gas facilities, and during recent benthic baseline surveys in the offshore Taranaki area have provided snapshots of some of the different fish species that may be present. These include gurnard (*Chelidonichthys kumu*), mackerel (*Trachurus novaezelandiae*), john dory (*Zeus faber*), identified species of hake (*Merlucciidae* sp), unidentified species of shark (Selachimorpha), sea perch (*Helicolenus percoides*), dogfish (*Squalus acanthias*.*)*, skate (*Dipturus nasutus*), anchovy (*Engraulidae* sp.), pilchard (*Clupeidae* sp.), opalfish (*Hemerocoetes monopterygius*), hagfish (*Eptatretus cirrhatus*), and several unidentified species of flatfish (SLR, 2018).

Table 9 lists the fish species potentially present in the Operational Areas. This information was collated from the Ministry of Primary Industries New Zealand fish guides (McMillan *et al.*, 2011a; 2011b) and more than 35 years of trawl surveys as reported in Anderson *et al.* (1998), Bagley *et al.* (2000), Hurst *et al.* (2000a, 2000b), and O'Driscoll *et al.* (2003). The present total (as of 2013) for the number of fish species identified within New Zealand's EEZ is 1,262 (Roberts *et al.*, 2015), therefore the table below is not intended to provide an exhaustive list of all species present in the Operational Areas, but instead simply lists the main species.

Table 9 Fish Species Potentially Present in the Operational Areas

Species – Common Name		
Anchovy [1]	Gurnard[1,2]	Rig[1,2]
Albacore tuna[2]	Hapuku[1,2]	Rough skate[1,2]
Barracouta[1,2]	Hoki[1,2]	Rubyfish[1,2]
Bass grouper[2]	Jack mackerel (*Trachurus novaezelandiae*)[1,2]	Scaly gurnard[1,2]
Blue cod[1,2]	Jack mackerel (*T. declivis*)[1,2]	School shark[1,2]
Blue mackerel[1,2]	Jock stewart[1]	Sea perch[1,2]
Blue moki [1]	John dory[1,2]	Shorttail stingray[1,2]
Blue shark[1,2]	Kahawai[1,2]	Silver warehou[1,2]
Blue warehou[1,2]	Kingfish[1,2]	Silverside[1,2]
Brill [1]	Leatherjacket[1,2]	Skipjack tuna[2]
Broadnose sevengill shark[2]	Lemon sole [1]	Slender tuna[1]
Brown stargazer[1, 2]	Ling[1,2]	Smooth skate[1,2]
Butterfly perch[1,2]	Long-tailed stingray [1]	Snapper[1,2]
Carpet shark[1,2]	Mako shark[1,2]	Southern conger[2]
Common roughy[1,2]	Murphy's mackerel[1,2]	Southern lemon sole[1]
Conger eels[1]	New Zealand sole [1]	Spiny dogfish[1,2]
Cucumberfish[1,2]	Northern spiny dogfish[1,2]	Spotted gurnard[1,2]
Dark ghost shark[1,2]	Opalfish (*Hemerocoetes* sp.) [1]	Spotted stargazer[1,2]
Electric ray[1,2]	Orange perch[1]	Sprat (*Sprattus antipodum* and *S. muelleri*) [1]
Elephant fish [1]	Pilchard[1,2]	Tarakihi[1,2]
Frostfish[1,2]	Porbeagle shark[1,2]	Thresher shark[1,2]
Gemfish[1,2]	Porcupine fish[1,2]	Trevally[1,2]
Giant stargazer[1,2]	Ray's bream[2]	Turbot [1]
Goatfish [2]	Red cod[1,2]	White trevally[2]
Greenback flounder [1]	Redbait[1,2]	Witch [1,2]

1 Trawl surveys (Anderson *et al.*, 1998; Bagley *et al.*, 2000; Hurst *et al.*, 2000a, 2000b; O'Driscoll *et al.*, 2003)

2 McMillan *et al.,* 2011a, 2011b

5.2.4.1 Freshwater Eels

Within New Zealand waters there are two main species of freshwater eel: the endemic long-finned eel (*Anguila dieffenbachii*) and the short-finned eel (*A. australis schmidtii*). As well as being found in New Zealand, the short-finned eel also occurs throughout Australia. A third species, the spotted eel (*A. reinhardtii*), has recently been found in northern rivers of New Zealand, where it is thought to be a new arrival from Australia (Te Ara, 2018d). Under the New Zealand Threat Classification System (Dunn *et al.*, 2018) long-finned eels are classified as 'Declining' and short-finned eels as 'Not Threatened'. Both species are commercially harvested and managed under New Zealand's Quota Management System (Jellyman, 2012).

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

- Elvers (juvenile two-year-old eels) move from the marine environment into freshwater habitats from October to December. These young eels move at night, during floods, or on overcast days (Jellyman, 1977) during which time they find suitable cover and feeding grounds in the lower reaches of streams. Here they remain for the next four to five years (Cairns, 1950);
- Following the influx of the elvers, the four- to five-year-old eels begin an upstream migration. This migration further upstream occurs annually in January (Cairns, 1950); and
- The third migration involves the movement of sexually mature adult eels (known to Māori as tuna heke or tuna whakaheke) to spawning grounds. This migration occurs in February and March, with the majority of eels having migrated by April, and follows a distinct pattern. Mature females begin by moving to brackish waters where they join the mature males. First to enter the sea are short-finned males followed by short-finned females (Cairns, 1950; Todd, 1981). Long-finned eels show a similar pattern with their migrations occurring after that of the short-finned eel (Cairns, 1950; Todd, 1981). It has been suggested that the movement of sexually mature adult eels is influenced by the lunar cycle (Todd, 1981). Adults move to the sub-tropical Pacific Ocean and although the exact location and migration route for spawning is not known (as eel spawning has never been observed), deep ocean trenches near Fiji and New Caledonia are thought to be important spawning grounds (NIWA, 2019b). Short-finned and long-finned eels are semelparous; that is they breed only once at the end of their life (NIWA, 2019b), resulting in no southern migration of adults returning to New Zealand.

A fourth, unobserved migration occurs involving the leptocephalus young (transparent leaf-shaped eel larvae). The leptocephalii reach New Zealand waters by drifting on ocean currents. Once reaching New Zealand coastal waters they morph into eel-shaped 'glass eels' and move into river mouths and estuaries (Te Ara, 2018d). Glass eels are generally sedentary during their first year in fresh water (Jellyman, 1977). Following a year spent in river mouths and estuaries the glass eels commence their freshwater life-cycle as elvers (see first point).

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

5.2.4.2 Protected Species

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

White sharks are classified under the New Zealand threat classification system as 'Nationally Endangered' (Duffy *et al*., 2018). Recent genetic analysis has estimated the total abundance of great whites in eastern Australia and New Zealand (considered to be a single population) to be approximately 280 – 650 adults, with a total population of approximately 2,500 – 6,750 (Hillary *et al*., 2018).

White sharks occur widely in New Zealand waters, from the subtropical Kermadec Islands to the subantarctic Campbell Island (Francis *et al.,* 2015). Little is known of their New Zealand habitat use; however, juveniles and adults are known to occur in shallow coastal waters (including large harbours and estuaries) where they feed largely on fish (DOC, 2019) and white sharks are relatively common along New Zealand's northwest coast (Duffy *et al.,* 2012). Sub-adults and adults also utilise waters of the open ocean and around offshore islands and banks. Once the sharks reach approximately 3 m in length, they begin to also feed on marine mammals (DOC, 2019). As such, subadult and adult white sharks tend to aggregate near seal colonies, although major aggregation sites for subadults and adults are only known in southern New Zealand and the Chatham Islands.

Sightings of white sharks in Taranaki waters are not rare, with records along the Taranaki coast throughout most of the year (C. Duffy in RNZ, 2019). A large 5 – 6 m female shark nicknamed the 'Taranaki Terror' or 'Mrs White' was first sighted in Taranaki in 2004 and was regularly sighted for a number of years around areas such as the Sugar Loaf Islands. Sightings of a large white shark off the New Plymouth breakwater in 2016 suggested that the 'Taranaki Terror' continues to use Taranaki waters, or is not the only large white shark to occur in the region (Reive, 2016).

5.2.4.3 Fish Spawning

Species potentially spawning/pupping within the Operational Areas have been provided in **Table 10** based on Morrison *et al.* (2014), Hurst *et al.* (2000b) and O'Driscoll *et al.* (2003). Spawning and pupping areas of New Zealand's fishes are, however, generally not well known as such data is typically difficult to obtain (Hurst *et al.*, 2000b).

Table 10 Fish Species Potentially Spawning in or near the Operational Areas

Species	Spawning Season	Species	Spawning Season
Anchovy	Spring – autumn	John dory	Summer (peak in February)
Barracouta	Late winter – spring	Lemon sole	June – December
Blue cod	Late winter – spring	Kingfish	Spring – summer
Blue mackerel	November – April	Ling	Spring and early summer
Blue warehou	Winter – spring	Murphy's mackerel	Later winter – summer
Elephant fish	Spring – summer	New Zealand sole	Autumn – spring
Giant stargazer	Winter	Pilchards	November – February
Gurnard	Summer and autumn	Red cod	July – September
Hoki	Winter	Rough skate	Spring – summer
Jack mackerel (*T. declivis*)	Spring	Sprat	Winter – spring
Jack mackerel (*T. novaezelandiae*)	Spring	Tarakihi	Summer – autumn

5.2.5 Cephalopods

Four groups of cephalopods are represented in New Zealand waters: squid (order Teuthida), octopus (order Octopoda), vampire squid (order Vampyromorphida) and cuttlefish (order Sepiida). Octopus and squid are an invaluable food source for a number of bird, mammal and fish predators, and are typically short-lived (1 – 2 years), fast growing and only spawn once before dying (MFish, 2008).

Forty-two octopus species are recognised from New Zealand waters; of these, 68% are endemic (O'Shea, 2013). Due to their affiliation with reef habitats, the Operational Areas are not considered to be important habitats for octopuses. However, benthic monitoring around Taranaki oil fields have reported the occasional juvenile *Macroctopus maorum* in samples and hence it is possible that this species could be present in the Operational Areas. The small *Octopus huttoni* is also found throughout New Zealand in the intertidal and subtidal to depths of 250 m (Marinelife, 2019), so may also occur in and within the Operational Areas.

New Zealand has a diverse assemblage of squid, vampire squid and cuttlefish; with more than 85 species recorded (Te Ara, 2019e). The majority of these species are pelagic and inhabit open water habitat. The cuttlefish, *Sepioloidea pacificais*, has more of an inshore distribution; occurring in soft sediments around coastal New Zealand (Marinelife, 2019).

The New Zealand squid fishery focusses on two species of arrow squid; Gould's arrow squid (*Nototodarus gouldi*) and Sloan's arrow squid (*N. sloanii*). These species are found across the continental shelf in water depths up to 500 m but are most commonly caught in waters less than 300 m (MPI, 2017). *N. sloanii* is primarily found along New Zealand's south-east coast and has been reported on the west coast of the North Island as far north as Cape Egmont. In comparison, *N. gouldi* is found off the west and east coasts of the North Island, and the central, north-west, and north-east coasts of the South Island as far south as Banks Peninsula (Smith *et al.*, 1987).

The majority of squid fishing activity takes place in the summer months from January through to May. Arrow squid have been caught within the Taranaki Bight during research trawl surveys (Bagley *et al.*, 2000); however, they are not commercially targeted here, as 95% of New Zealand's squid catch is taken by deepwater trawls from southern and sub-Antarctic fishing grounds, while jigging coastal vessels catch the rest in calmer, more northern waters (Deepwater Group, 2019).

5.2.6 Cetaceans

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

Baleen whales are characterised by the presence of plates of baleen in the mouth and occur throughout the world in a range of habitats from coastal areas out to deep pelagic waters (Clapham *et al.*, 1999). The majority of baleen whales undertake large seasonal migrations between high-latitude summer feeding grounds and winter mating and calving areas in warmer, low-latitude waters. While migration routes vary between species, high mobility and movements across international boundaries is a general feature of most baleen whales (Clapham *et al.*, 1999).

The annual migrations of most species of baleen whale in the southern hemisphere are somewhat predictable. Whales travel south in spring to feed in Antarctic waters over summer returning north to temperate and tropical breeding grounds in autumn and winter (DOC, 2007). In New Zealand waters, Bryde's and pygmy blue whales are an exception as they do not exhibit clear migratory patterns and instead are considered resident or semi-resident to particular habitats or areas. More detailed descriptions of the known migratory pathways are provided in the individual species accounts below.

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

The sections below summarise which cetacean species could be present within the Operational Areas. Due to the highly mobile nature and large home ranges of cetaceans, the Gladstone-1, Toutouwai-1, and Māui-8 Operational Areas have been assessed together.

5.2.6.1 Cetacean Species that could be Present

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

- Sightings data:
  - From previous seismic surveys undertaken for OMV and other operators (obtained from DOC marine mammals sightings database);
  - From opportunistic sightings (obtained from DOC marine mammals sightings database);
  - From operator work vessels, including OMV's (obtained from the DOC marine mammal sightings database). OMV stipulates that all vessels working on their behalf record any marine mammal sightings, which are subsequently provided to DOC[1];
- Stranding data (obtained from the DOC marine mammals stranding database); and
- Knowledge of migration paths and habitat preferences of each species (obtained from published literature).

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

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

Previous assessments of marine mammal distribution off the Taranaki coastline note that the area is well used by a large number of marine mammal species with extensive home ranges. For this reason, it was considered that undertaking a marine mammal analysis on the small Operational Areas for each well location (as shown in **Figure 1**) would be inappropriate as it would most certainly lead to an under-estimate of the species that could potentially be present at each well location. On this basis a more extensive marine mammal Area of Interest (**AOI**) was used to describe the species potentially affected by the Taranaki Checkshot Surveys as shown in **Figure 11**. This is the combined AOI (i.e. northern, central and southern AOI) that was used within the Taranaki EAD Programme marine consent application.

[1] As a condition for the 2013 Maari development drilling (EEZ000007), a condition of OMV's consent was to report all Hector's and Māui's dolphins to DOC. OMV has since adopted this for all marine mammals and applied it to all of their operations.

Likewise, the interpretation of the stranding data has included of the coastlines of the Taranaki, Whanganui/Manawatu, south Waikato, Tasman, Golden Bay and Marlborough regions. Following this conservative approach provides the best opportunity that all marine mammal species that may occasionally be present at these locations are identified and their possible presence in the vicinity of the Taranaki Checkshot Surveys can be assessed in context of their wider habitat use.

Figure 11 provides a summary of all sightings recorded in the DOC marine mammal sightings database in the vicinity of the Operational Areas and the marine mammal AOI that was also assessed. **Figure 12** provides a summary of the DOC stranding records along the coastline inshore of the Operational Areas, focusing directly inshore around Cape Egmont. The criteria used to determine the likelihood of a cetacean species being present in the Operational Areas are presented in **Table 11**. The findings of the assessment are summarised in **Table 12**, while a basic ecological summary for those species assessed as being 'likely', 'possible' or 'occasional visitors' to the Operational Areas is provided in each species sub-section.

Table 11 Criteria Used to Assess the Likelihood of Cetacean Species Being Present

Likely	Species that are represented in the DOC sightings and/or stranding record from the Marine Mammal AOI and which are not classified as 'Vagrant' in the New Zealand Threat Classification System (Baker *et al.*, 2019) and for which a reasonable number of sightings or strandings are reported for the AOI.
Occasional Visitor	Species that are represented in the DOC sightings and/or stranding record from the Marine Mammal AOI but are listed as 'Migrant' in the New Zealand Threat Classification System (Baker *et al.*, 2019) or for which few sightings or strandings are reported for the AOI. Note that this criterion does not preclude some 'Migrant' species from being assessed as being 'likely' to occur in the Operational Areas.
Rare Visitor	Species that are present in the DOC sightings and/or stranding record from the Marine Mammal AOI, or reportedly occur in the Marine Mammal AOI, or whose known range is directly adjacent to the Marine Mammal AOI but are listed as 'Vagrant' in the New Zealand Threat Classification System (Baker *et al.*, 2019).
Unlikely	Those species not represented in the DOC sightings and/or stranding record from the Marine Mammal AOI.

Note: Where only very small numbers of sightings or strandings are present in the DOC Strandings and Sighting Databases, likelihood determination has been adjusted to take any additional information into consideration.

Figure 11 Cetacean Sightings in the Vicinity of the Operational Areas

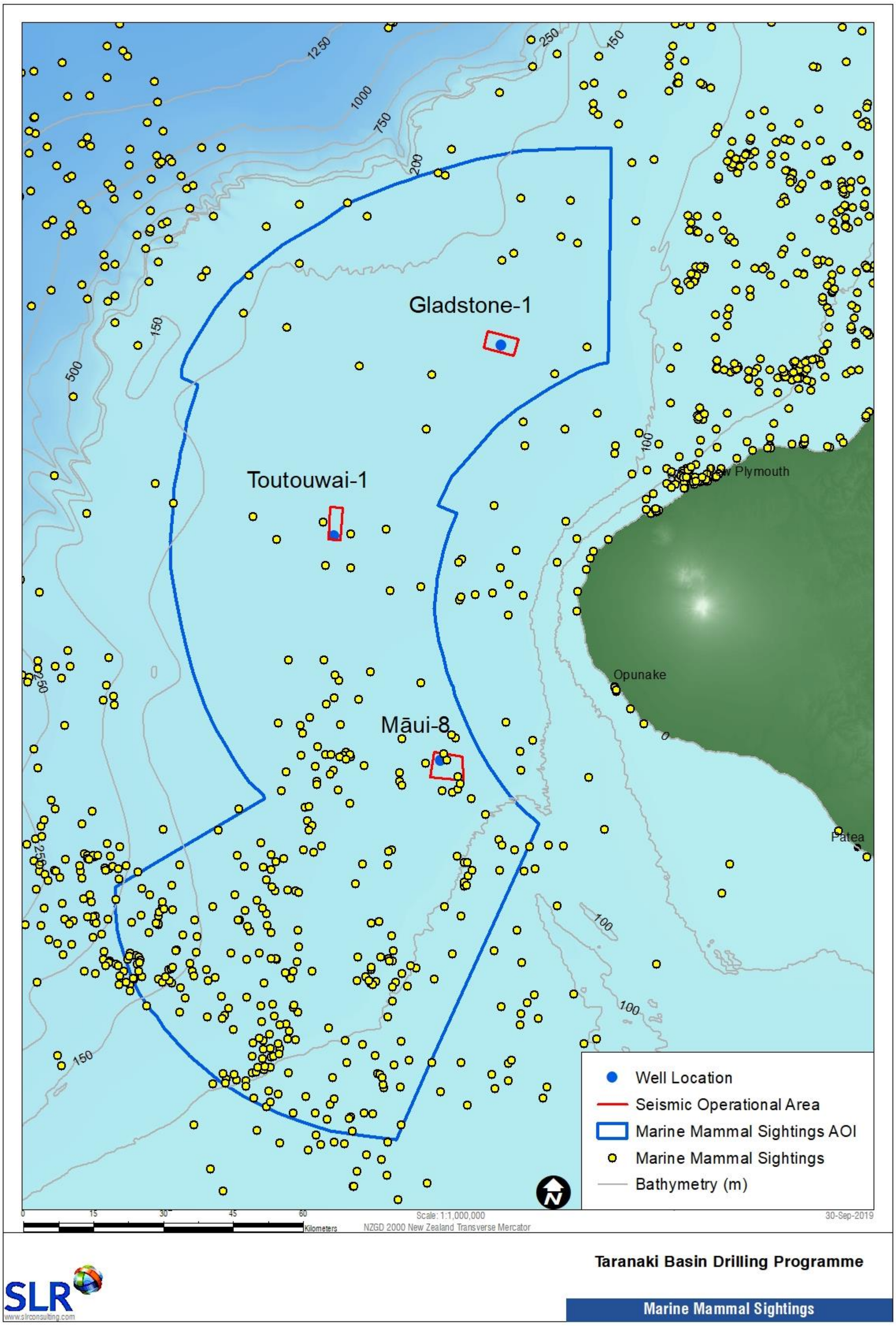
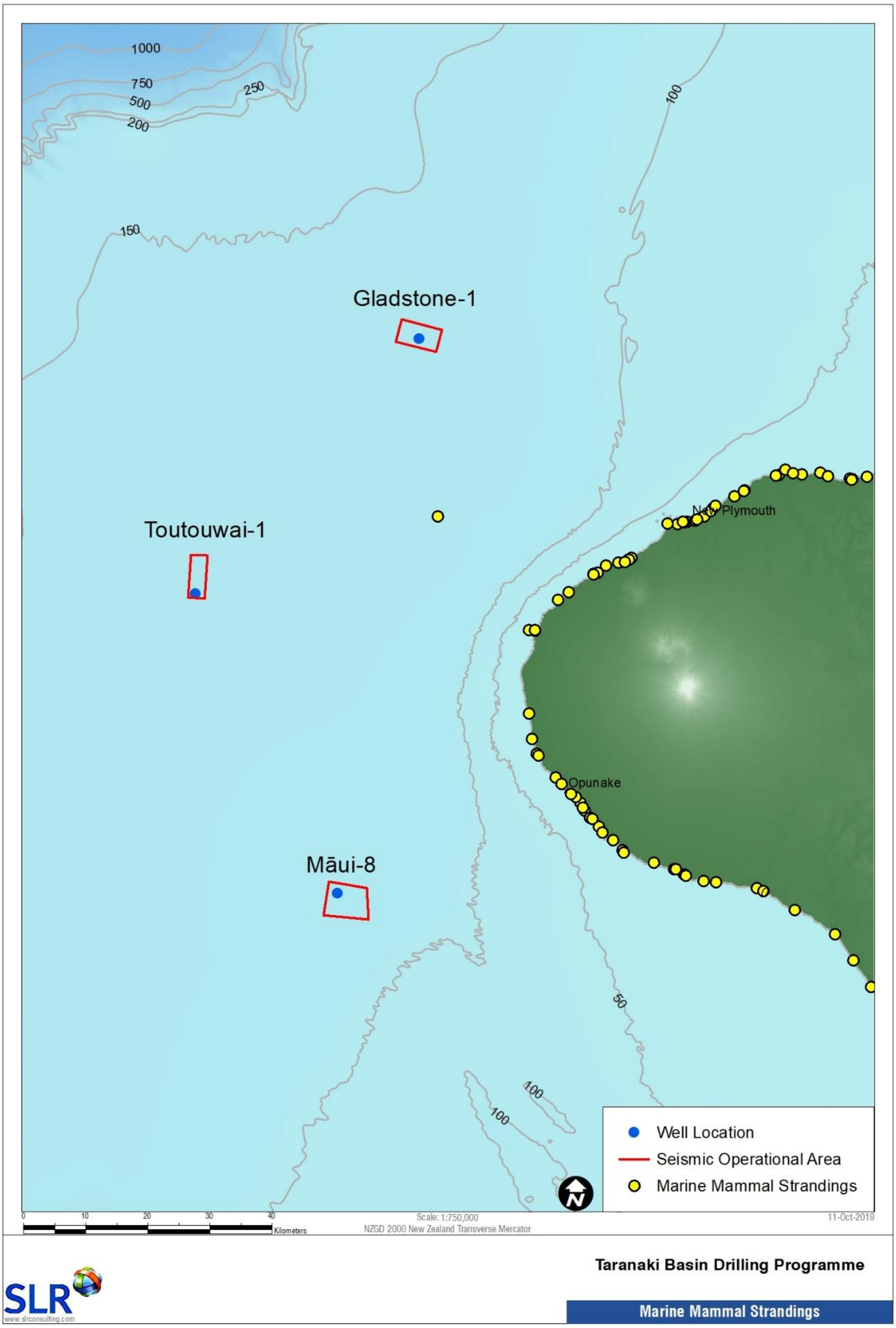


Figure 12 Cetacean Stranding Events Inshore of the Operational Areas



Note: Standing located NW of Cape Egmont was a Baleen whale found floating at sea.

Table 12 New Zealand Marine Mammals and their Likelihood of Occurrence within the Operational Areas

Common Name	Scientific Name	NZ Conservation Status (Baker *et al.*, 2019)	Qualifier *	IUCN Conservation Status www.redlist.org	Species of Concern (DOC, 2013)	DOC Stranding database (No. of events inshore of Operational Areas **)	DOC Sightings database (No. of reports in Marine Mammal AOI)	Presence in the Operational Areas
Andrew's beaked whale	*Mesoplodon bowdoini*	Data deficient	S?O	Data deficient	✓	✓ (4)	×	**Likely**
Antarctic blue whale	*Balaenoptera musculus intermedia*	Data deficient	TO	Critically endangered	✓	✓ (5)	✓ (****)	**Likely**
Antarctic fur seal	*Arctocephalus gazella*	Vagrant	SO	Least Concern	×	×	×	Unlikely
Antarctic minke whale	*Balaenoptera bonaerensis*	Data deficient	DP, SO	Data deficient	✓	✓ (2)	×	**Likely**
Arnoux's beaked whale	*Berardius arnuxii*	Data deficient	S?O	Data deficient	✓	✓ (6)	×	**Likely**
Blainville's/Dense beaked whale	*Mesoplodon densirostris*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Bottlenose dolphin	*Tursiops truncatus*	Nationally endangered	De, PF, SO, Sp	Least concern	✓	✓ (16)	✓ (1)	**Likely**
Bryde's whale	*Balaenoptera edeni*	Nationally critical	CD, DP, SO	Data deficient	✓	✓ (2)	✓ (2)	**Occasional Visitor**
Common dolphin	*Delphinus delphis*	Not threatened	DP,SO	Least concern	×	✓ (77)	✓ (37)	**Likely**
Crab eater seal	*Lobodon carcinophaga*	Vagrant	SO	Least concern	×	×	×	Unlikely
Cuvier's beaked whale	*Ziphius cavirostris*	Data deficient	SO	Least concern	✓	✓ (20)	✓ (1)	**Likely**
Dusky dolphin	*Lagenorhynchus obscurus*	Not threatened	S?O	Data deficient	×	✓ (32)	✓ (2)	**Likely**
Dwarf minke whale	*Balaenoptera acutorostrata*	Data deficient	DP, SO	Least concern	✓	✓ (12)	×	**Likely**
Dwarf sperm whale	*Kogia sima*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
False killer whale	*Pseudorca crassidens*	Naturally uncommon	DP, T?O	Data deficient	✓	✓ (3)	✓ (1)	**Likely**
Fin whale	*Balaenoptera physalus*	Data deficient	TO	Endangered	✓	✓ (4)	✓ (2)	**Likely**
Fraser's dolphin	*Lagenodelphis hosei*	Data deficient	SO	Least concern	×	×	×	Unlikely
Gingko-toothed whale	*Mesoplodon ginkgodens*	Data deficient	S?O	Data deficient	✓	✓ (3)	×	**Occasional Visitor**
Gray's beaked whale	*Mesoplodon grayi*	Not threatened	S?O	Data deficient	✓	✓ (36)	×	**Likely**
Hector's beaked whale	*Mesoplodon hectori*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Hector's dolphin	*Cephalorhynchus hectori hectori*	Nationally vulnerable	CD, DP, PF	Endangered	✓	✓ (14)	✓ (1)	**Occasional Visitor *** **
Hourglass dolphin	*Lagenorhynchus cruciger*	Data deficient	SO	Least concern	×	×	×	Unlikely
Humpback whale	*Megaptera novaeangliae*	Migrant	SO	Least concern	✓	✓ (5)	✓ (2)	**Likely*** **
Killer whale	*Orcinus orca*	Nationally critical	DP, S?O, Sp	Data deficient	✓	✓ (2)	✓ (4)	**Likely**
Leopard seal	*Hydrurga leptonyx*	Naturally uncommon	De, SO	Least concern	×	×	×	Unlikely
Lesser/pygmy beaked whale	*Mesoplodon peruvianus*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Long-finned pilot whale	*Globicephala melas*	Not threatened	DP, S?O	Data deficient	✓	✓ (72)	✓ (7)	**Likely**
Māui's dolphin	*Cephalorhynchus hectori maui*	Nationally critical	CD	Not assessed	✓	✓ (18)	✓ (2)	**Occasional Visitor *** **
Melon-headed whale	*Peponocephala electra*	Vagrant	SO	Least concern	✓	×	×	Unlikely
New Zealand sea lion	*Phocarctos hookeri*	Nationally vulnerable	CD, RR	Endangered	✓	×	×	Unlikely
New Zealand fur seal	*Arctocephalus forsteri*	Not threatened	Inc, SO	Least Concern	×	×	✓ (many)	**Likely**
Pantropical spotted dolphin	*Stenella attenuata*	Vagrant	SO	Least concern	×	✓ (1)	×	Rare visitor
Pygmy blue whale	*Balaenoptera musculus brevicauda*	Data deficient	S?O	Data deficient	✓	✓ (3)	✓ (****)	**Likely**
Pygmy killer whale	*Feresa attenuata*	Vagrant	DP, S?O	Data deficient	✓	×	×	Unlikely
Pygmy right whale	*Caperea marginata*	Data deficient	S?O	Data deficient	✓	✓ (18)	×	**Likely**
Pygmy sperm whale	*Kogia breviceps*	Data deficient	DP, S?O	Data deficient	✓	✓ (16)	×	**Likely**
Risso's dolphin	*Grampus griseus*	Data deficient	SO	Least concern	×	✓ (2)	×	**Occassional Visitor**
Ross seal	*Ommatophoca rossii*	Vagrant	SO	Least concern	×	×	×	Unlikely
Rough-toothed dolphin	*Steno bredanensis*	Data deficient	SO	Least concern	×	×	×	Unlikely
Sei whale	*Balaenoptera borealis*	Data deficient	TO	Endangered	✓	✓ (1)	✓ (7)	**Likely**
Shepherd's beaked whale	*Tasmacetus shepherdi*	Data deficient	SO	Data deficient	✓	✓ (6)	×	**Likely**

Common Name	Scientific Name	NZ Conservation Status (Baker *et al.*, 2019)	Qualifier *	IUCN Conservation Status www.redlist.org	Species of Concern (DOC, 2013)	DOC Stranding database (No. of events inshore of Operational Areas **)	DOC Sightings database (No. of reports in Marine Mammal AOI)	Presence in the Operational Areas
Short-finned pilot whale	*Globicephala macrorhynchus*	Data deficient	S?O	Data deficient	✓	✓ (1)	✓ (1)	**Occasional Visitor**
Southern bottlenose whale	*Hyperoodon planifrons*	Data deficient	SO	Least concern	✓	✓ (2)	×	**Occassional Visitor**
Southern elephant seal	*Mirounga leonina*	Nationally critical	RR, SO	Least concern	×	×	✓ (1)	Rare visitor ***
Southern right whale	*Eubalaena australis*	Recovering	OL, RR, SO	Least concern	✓	✓ (1)	✓ (3)	**Likely**
Southern right whale dolphin	*Lissodelphis peronii*	Data deficient	DP,S?O	Data deficient	✓	✓ (8)	×	**Occasional Visitor *** **
Spade-toothed whale	*Mesoplodon traversii*	Data deficient	S?O	Data deficient	×	×	×	Unlikely
Spectacled porpoise	*Phocoena dioptrica*	Data deficient	S?O	Data deficient	×	✓ (1)	×	**Occassional Visitor**
Sperm whale	*Physeter macrocephalus*	Data deficient	DP, TO	Vulnerable	✓	✓ (28)	✓ (1)	**Likely**
Strap-toothed whale	*Mesoplodon layardii*	Data deficient	S?O	Data deficient	✓	✓ (13)	×	**Likley**
Striped dolphin	*Stenella coeruleoalba*	Data deficient	SO	Least concern	×	✓ (1)	×	**Occassional Visitor**
Subantarctic fur seal	*Arctocephalus tropicalis*	Vagrant	SO	Least concern	×	×	×	Unlikely
True's beaked whale	*Mesoplodon mirus*	Data deficient	S?O	Data deficient	✓	×	×	Unlikely
Weddell seal	*Leptonychotes weddelli*	Vagrant	SO	Least concern	×	×	×	Unlikely

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

** Stranding data from the following locations was deemed to be of relevance to the Operational Areas: South Waikato, Taranaki, Whanganui/Manawatu, Outer Marlborough Sounds, Golden Bay, and Tasman Bay.

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

**** The number of sightings of blue whales is difficult to interpret as the DOC Sighting Database records most sightings as *Balaenoptera musculus* (i.e. without subspecies identification). In total the data base holds 130 sighting records for *Balaenoptera musculus* spp. Based on the recent findings of Torres *et al.* (2017), it is likely that the majority of these sightings are of *Balaenoptera musculus brevicauda* (pygmy blue whales)

5.2.6.2 Baleen Whales (suborder Mysticeti)

5.2.6.2.1 Southern right whale (*Eubalaena australis*)

Southern right whales exhibit a seasonal distribution, spending summer months feeding in latitudes between 40 and 50°S (Oshumi & Kasamatsu, 1986) and winter months breeding in more temperate coastal habitat. Migratory routes of southern right whales span thousands of kilometres, and encompass a range of habitats from sheltered coastal wintering grounds to offshore summer feeding grounds (Carroll *et al*., 2011). Summer distribution at feeding grounds is likely linked to the distribution of prey (Tormosov *et al*., 1998), although maternally directed learning of migratory destinations is also evident in this species (Jackson *et al*., 2016). While on seasonal feeding grounds the whales feed on dense euphausiid (krill) and copepod aggregations (Tormosov *et al.*, 1998; Rowantree *et al.*, 2008). Southern right whales are specialised 'skimmers' that feed by swimming slowly with their mouths wide open through prey aggregations, usually below the sea surface (Braham & Rice, 1984).

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

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

Southern right whales have been sighted within the Marine Mammal AOI and one southern right whale stranding has been reported inshore of the Operational Areas. Based on this, it is ***possible*** that southern right whales could be present in the Operational Areas.

5.2.6.2.2 Pygmy right whale (*Caperea marginata*)

Pygmy right whales are the smallest, most cryptic and least known of the living baleen whales (Fordyce & Marx, 2012). Pygmy right whales are known to have a worldwide distribution and a diet consisting largely of calanoid copepods and euphausiids (Kemper, 2002). In New Zealand, sightings typically occur near Stewart Island and Cook Strait (Kemper, 2002). Kemper (2013) suggests an association between pygmy right whales and areas of high marine productivity.

Little information is known on the vocalisations of pygmy right whales, although it has been assumed that communication is similar to other baleen whales, in that this species communicates using loud low-pitched sounds (WhaleFacts, 2019). Pygmy right whale recordings have documented calls of paired short thump-like pulses or tone bursts with a down-sweep in frequency and decaying amplitude. The energy of these calls was between 60 and 120 Hz, and recorded source levels were in the lower end of the range of baleen whale calls (Dawbin & Cato, 1992).

There have been no sightings of pygmy right whales in the Marine Mammal AOI; however, a number of strandings have been reported inshore. Strandings occurred predominantly in Golden Bay, as well as in Taranaki and the outer Marlborough Sounds. Based on the stranding records it is ***possible*** pygmy right whales could be present in the Operational Areas.

5.2.6.2.3 Minke whales (*Balaenoptera acutorostrata* and *B. bonaerensis*)

Antarctic minke whales (*B. bonaerensis*) and dwarf minke whales (*B. acutorostrata*) both occur in New Zealand waters. The distribution of the Antarctic minke is restricted to the southern hemisphere where it is very abundant in Antarctic waters in summer. This species is seen at lower latitudes in other seasons, although outside of the summer months their distribution is less well-known (Reilly *et al*., 2008). The dwarf minke occurs over most latitudes in both hemispheres. In the southern hemisphere, they too feed in Antarctic waters in summer, with a broader latitudinal distribution in other seasons (Reilly *et al*., 2008).

The DOC sighting and stranding data indicate that the distribution of minke whales extends around mainland New Zealand and throughout New Zealand's sub-Antarctic waters. There were 60 reported sightings of minke whales (both species) in New Zealand's EEZ between 1970 and 2013, the majority of which were in spring (38%). This timing aligns well with the southern migration towards Antarctic feeding grounds (Berkenbusch *et al.*, 2013). Minke whales feed on planktonic crustaceans and small schooling fish (e.g. anchovy and herring); with fish comprising a higher proportion of their diet compared to other baleen whales.

Recordings of a population of dwarf minke whales off Australia's Great Barrier Reef revealed complex vocalisations that span a wide frequency range (50 Hz – 9.4 kHz) and are composed of distinct repeated units. Broadband source levels for the recorded vocalisations were calculated to be 150 – 165 dB re 1 µPa @ 1 m (Gedamke *et al*., 2001).

There have been no sightings of minke whales (of either species) within the Marine Mammal AOI; however, 14 stranding events (two Antarctic minke and 12 dwarf minke) have been reported along the coastline in the wider vicinity. Minke whales have stranded predominantly in Golden Bay, with South Waikato, Taranaki and Tasman Bay also represented in the stranding record. Based on this, it is ***likely*** that minke whales will utilise habitat within the Operational Areas.

5.2.6.2.4 Sei whale (*Balaenoptera borealis*)

Sei whales tend to prefer warmer water temperatures than other baleen whales (Mizroch *et al.*, 1984); their preferred water temperature is between 8 – 18 °C (Horwood, 2009). Sei whales from the South Pacific migrate to sub-Antarctic feeding grounds during late summer, spending the remainder of the year in subtropical waters (Miyashita *et al.*, 1995). Sei whales are surface feeders and have a diet that consists mostly of krill, copepods, and small fish (Baker, 1999).

Sei whale vocalisations have been recorded as low-frequency down-sweep calls that sweep from 82 to 34 Hz over 1.4 seconds, most often produced as a single call but occasionally as pairs or triplicates (Baumgartner *et al*., 2008). McDonald (2006) also recorded broadband sounds described as 'growls' or 'wooshes'. The maximum source level of tonal calls recorded by McDonald (2006) was 156 ±3.6 dB re 1 µPa @ 1 m.

Sei whales have been sighted within the Marine Mammal AOI and there has been a stranding event for this species in Golden Bay. As a result, sei whales may be ***occasional visitors*** to the Operational Areas.

5.2.6.2.5 Bryde's whale (*Balaenoptera edeni*)

Bryde's whales have a broad distribution throughout temperate and tropical waters of the Pacific, Indian and Atlantic Oceans. They differ from other large baleen whales in that they do not undertake seasonal migrations, and instead remain in waters 15 – 20°C between 40°N and 40°S (Yoshida & Kato, 1999; Best, 2001). Bryde's whales in temperate waters are thought to be semi-migratory and make local seasonal movements (Gaskin, 1968) to take advantage of prey aggregations (Kato, 2002; Reikkola, 2013; Carroll *et al*., 2019). Bryde's whales are one of the most common large whale species in New Zealand waters (Dawson, 1985).

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

There have been two Bryde's whale sightings from within the Marine Mammal AOI. Two stranding events have occurred along the coast at Foxton Beach (South Taranaki Bight) and Mokau (North Taranaki Bight). Based on these records, it is ***possible*** that Bryde's whales will utilise the Operational Areas.

5.2.6.2.6 Blue whales (*Balaenoptera musculus*)

There are two subspecies of blue whale known from New Zealand waters; the pygmy blue whale (*B. musculus brevicauda*) and the Antarctic blue whale (*B. musculus intermedia*). These two subspecies are difficult to distinguish without the use of genetic techniques, hence stranding and sighting data has not consistently differentiated between the two.

Recent research expeditions in the South Taranaki Bight identified a population of resident or semi-resident pygmy blue whales that (as evident from acoustic data and visual sightings) are non-migratory and present there throughout most of the year (Olson *et al.*, 2008, Torres *et al.*, 2017); during a year-long collection of acoustic recordings from Taranaki, blue whales were heard on 99.7% of days (as described in Childerhouse, 2018). Data collected since 2012 has identified the South Taranaki Bight as a blue whale foraging ground, with data suggesting whales target the krill *Nyctiphanes australis*. The absolute distribution of blue whales in the South Taranaki Bight has been found to vary with oceanographic patterns and the subsequent distribution of prey. In El Nino conditions whales tend to be located west of the Bight, but inside the Bight during more typical weather patterns (Torres & Klinck 2016). In February 2016, a field survey gathered the first evidence of breeding behaviour in the waters within and to the west of the South Taranaki Bight. High densities of mother/calf pairs were observed, and documentation included the first aerial footage of blue whale nursing behaviour (Torres & Klinck 2016).

The IUCN Red List of Threatened Species currently lists the Antarctic blue whale as 'Critically Endangered' and pygmy blue whale as 'Data Deficient'. In the latest DOC threat assessment for marine mammals, the threat classifications for Antarctic blue whales and pygmy blue whales were changed respectively from 'Not Threatened' and 'Migrant' to 'Data Deficient' (Baker *et al*., 2019) given the identification of the high number of blue whales in the South Taranaki Bight. Due to the lack of availability of trend and abundance data, a 'Data Deficient' classification was considered the most appropriate for these subspecies (Baker *et al*., 2019).

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

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

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

There have been a high number of blue whale sightings from within the Marine Mammal AOI as well as a number of stranding events from coastal areas inshore. Stranding events have occurred in South Waikato, Taranaki, Whanganui/Manawatu, the outer Marlborough Sounds, and Tasman Bay. Based on these records, it is ***likely*** that blue whales, particularly pygmy blue whales, will be present in the Operational Areas, with the highest densities occurring towards the south.

5.2.6.2.7 Fin whale (*Balaenoptera physalus*)

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

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

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

Sightings of fin whales have been made within the Marine Mammal AOI and stranding events have occurred along the coastline in Taranaki, Golden Bay, and Tasman Bay. Fin whales are believed to be ***occasional visitors*** to the Operational Areas.

5.2.6.2.8 Humpback whale (*Megaptera novaeangliae*)

Humpback whales are distributed throughout the North Atlantic, North Pacific, and Southern Hemisphere (Gibbs & Childerhouse, 2000) and undertake the longest migration of any mammal (Jackson *et al.*, 2014), feeding in the circumpolar waters of the Antarctic in summer and migrating to breeding grounds in sub-tropical or tropical waters in winter (Dawbin, 1956). Migrating whales typically use continental shelf waters (Jefferson *et al* 2008) and can approach closely to shore when passing headlands or moving through confined waters (e.g. Gibbs *et al*., 2017).

Humpback whale migration routes along the coast of New Zealand were first described by Dawbin (1956) with later descriptions by Gibbs and Childerhouse (2000) confirming a similar pattern. When migrating north the majority of whales move up the South Island's east coast towards Cook Strait. Here, the migration route splits with most whales passing through Cook Strait and up the North Island's west coast, with some individuals continuing north along the North Island's east coast (Gibbs & Childerhouse, 2000). The northward migration occurs from late May to early August (Dawbin, 1956). Although the breeding grounds of humpbacks that migrate past New Zealand have not been clearly identified, a number of studies have linked New Zealand humpbacks to breeding grounds in New Caledonia, Fiji and Tonga (Gibbs *et al*., 2017).

Southern migrating humpbacks pass along the west coast of the North and South Islands where they aggregate near the southwest corner of the South Island before moving further south. A small number of southern migrating whales pass the east coast of the North Island to East Cape where they depart offshore (Gibbs & Childerhouse, 2000). Recent satellite tagging of southern-migrating whales has revealed those that travel to the east of New Zealand typically congregate at the Kermadec Islands before proceeding south to two recently discovered Southern Ocean feeding areas (Riekkola *et al*., 2019). Southern migrations occur from mid-September to early December (Dawbin, 1956).

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

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

Humpback whales are occasionally seen in coastal Taranaki waters, particularly between the months of May and August on their northern migration. Humpback whales have been sighted within the Marine Mammal AOI and there have been a number of stranding events inshore; four in Taranaki and one in Tasman Bay. Based on this assessment it is considered that humpback whales ***likely*** be in the Operational Areas, particularly in late spring/early winter.

5.2.6.3 Toothed Whales (suborder Odonotoceti)

5.2.6.3.1 Sperm whale (*Physeter macrocephalus*)

Sperm whales have a wide geographical and latitudinal distribution. They forage primarily for squid by carrying out long dives that can last over an hour (Evans & Hindell, 2004; Gomez-Villota, 2007). Smaller volumes of various species of fish also contribute to the diet of sperm whales (Gaskin & Cawthorn, 1967).

Systematic surveys of sperm whale distribution in New Zealand are limited to the Kaikoura region, which is home to a small number of resident male sperm whales that feed in the submarine canyons (Arnold, 2004).

While sperm whales do not carry out large scale migrations like those of the baleen whales, smaller movements occur, with males and females in the Southern Hemisphere moving southward from the equator during winter months (April – September), returning north in summer (October – March) (Berzin, 1971).

Sperm whales rely on echolocation to locate prey and navigate, with foraging clicks allowing the whales to determine the direction and distance of prey (Ocean Research Group, 2015). Clicks are also produced as a means of communication, to identify members of a group and to coordinate foraging activities (Andre & Kamminga, 2000). Sperm whale clicks have been reported to be multi-pulsed and broadband, ranging in frequency from 0.2 – 32 kHz (Backus & Schevill, 1966). Clicks from foraging male sperm whales have been recorded with source levels up to 236 dB re 1 µPa @ 1 m (Madsen *et al.,* 2002; Møhl *et al.,* 2003).

Torres (2012) reported that sperm whale sightings in Taranaki typically occurred in deep offshore water and were limited to the summer months. There has been one sperm whale sighting reported in the Marine Mammal AOI, and 29 stranding events inshore along the coast. The majority of sperm whale stranding events occurred in Taranaki and Golden Bay; however, stranding records also exist for South Waikato, Whanganui/Manawatu, and Tasman Bay. A recent stranding event in May 2018 occurred at Kaupokonui Beach in South Taranaki. This event involved the stranding of eight adult male sperm whales, followed by the stranding of a further four adult males. Two weeks later a lone adult male stranded further along the coastline. This lone male is considered to be from the same pod as the original 12 stranded whales (Smith, 2018). Full necropsies were unable to be carried out due to the decomposed state of the animals (Angus, in press). Based on these records, sperm whales are ***likely*** to be present in the Operational Areas.

5.2.6.3.2 Pygmy sperm whales (*Kogia breviceps*)

Pygmy sperm whales are seldom seen at sea on account of their low profile in the water and lack of a visible blow; for this reason, little information is available on this species. Prey items of pygmy sperm whales include cephalopods, fish and occasionally crustaceans (Shirihai & Jarrett, 2006). They are deep divers but do not restrict their feeding only to deeper areas (Dawson, 1985).

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

Despite no live sightings being recorded for the Marine Mammal AOI, 16 stranding's of pygmy sperm whales have been reported on the coast (from South Waikato, Taranaki and Whanganui/Manawatu). Pygmy sperm whales are therefore considered ***likely*** to occur in the Operational Areas.

5.2.6.3.3 Beaked whales (Family Ziphiidae)

Although, thirteen species of beaked whales have been reported in New Zealand (Baker *et al.*, 2016), their elusive behaviour at sea means that very little is known about their distributions (Baker, 1999). Most of the knowledge about beaked whales comes from stranded individuals. One live sighting of a beaked whale has been made within the South Taranaki Bight close to the Māui-8 Operational Area; this was of a pair of Cuvier's beaked whales observed travelling close to the Māui-B Platform.

Table 13 outlines those species that have stranded inshore of the Operational Areas and provides a brief account of the ecology of each species. They are deep divers and feed predominantly on deep-water squid and fish species. From the assessment provided in **Table 13**, the following conclusions can be drawn:

- Five species are ***likely*** to be present in the Operational Areas – Andrew's beaked whale, Arnoux's beaked whale, Gray's beaked whale, Strap-toothed whale, and Cuvier's beaked whale;
- Two species could ***occasionally visit*** the Operational Areas - Ginkgo-toothed whale and southern bottlenose whale; and
- Five species are ***unlikely*** to occur in the Operational Areas - Blainville's/Dense beaked whale, Hector's beaked whale, Lesser/pygmy beaked whale, True's beaked whale, Spade-toothed whale.

Table 13 Beaked Whale Ecology of Relevance to the Operational Areas

Species	No. of Stranding Events inshore of Operational Areas	Ecology
Arnoux's beaked whale *(Berardius arnuxii)*	Whanganui/Manawatu x 4 Taranaki x 1 Marlborough Sounds x 1 **TOTAL = 6**	Circumpolar distribution in deep, cold temperate and sub-polar waters. Considered to be naturally rare throughout its range; however, higher densities may occur seasonally in Cook Strait (Taylor *et al*., 2008). New Zealand has the highest number of stranding recorded for this species (Jefferson *et al.*, 1993).
Andrew's beaked whale *(Mesoplodon bowdoini)*	Golden Bay x 1 Whanganui/Manawatu x 1 Taranaki x 2 **TOTAL = 4**	Found between 32°S and 55°S in the Southern Hemisphere. Presumed to inhabit deep, offshore waters (Pitman & Stinchcomb, 2002). Based on the global stranding record, New Zealand might represent an area of concentration (Taylor *et al.*, 2008a).
Gingko-toothed whale *(Mesoplodon ginkgodens)*	Golden Bay x 1 Tasman Bay x 1 Taranaki x 1 **TOTAL = 3**	Most stranding and capture records for this species are from the tropical and warm temperate waters of the Indo-Pacific (esp. Japan). Only a few records from New Zealand. Biology is unknown (Taylor *et al*., 2008b).
Gray's beaked whale *(Mesoplodon grayi)*	Golden Bay x 4 Tasman Bay x 11 Marlborough Sounds x 1 Whanganui/Manawatu x 8 Taranaki x 10 South Waikato x 2 **TOTAL = 36**	A Southern Hemisphere species with a circumpolar distribution south of 30°. Many sightings are from Antarctic and sub-Antarctic waters. Many stranding records are from the coastline of New Zealand implying they may be fairly common here. Occurs in deep waters beyond the shelf edge (Taylor *et al.*, 2008c). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).

Species	No. of Stranding Events inshore of Operational Areas	Ecology
Strap-toothed whale *(Mesoplodon layardii)*	Golden Bay x 5 Tasman Bay x 1 Whanganui/Manawatu x 3 Taranaki x 4 **TOTAL = 13**	Occur between 35-60°S in cold temperate waters. Stranding seasonality suggest this species may migrate. Prefer deep waters beyond the shelf edge. Probably not as rare as other *Mesoplodon* sp. (Taylor *et al*., 2008d). Feeds on squid (Sekiguchi *et al.*, 1996). Acoustic recordings of this species have recently been made in Cook Strait (Goetz, 2017).
Southern bottlenose whale *(Hyperoodon planifrons)*	Golden Bay x 1 Whanganui/Manawatu x 1 **TOTAL = 2**	Circumpolar distribution in Southern Hemisphere, south of 30°. Common in Antarctic waters in summer. Typically occurs over submarine canyons in waters deeper than 1,000 m (Taylor *et al.*, 2008e).
Shepherd's beaked whale *(Tasmacetus shepherdi)*	Tasman Bay x 1 Whanganui/Manawatu x 1 Taranaki x 4 **TOTAL = 6**	A circumpolar distribution in cold temperate waters is presumed. All stranding events have occurred south of 30°, the majority from New Zealand. Thought to be relatively rare. Occur in deep water usually well offshore. Diet contains fish, squid and crabs (Braulik, 2018).
Cuvier's beaked whale *(Ziphius cavirostris)*	Golden Bay x 1 Tasman Bay x 4 Whanganui/Manawatu x 8 Taranaki x 5 South Waikato x 2 **TOTAL = 20**	Thought to have the largest range of any beaked whale found in deep waters (> 200 m) of all oceans in both hemispheres. Thought to prefer steep bathymetry near the continental slope in water depths greater than 1,000 m. Feed mostly on squid and dive up to 40 minutes. Global abundance is likely to be well over 100,000 (Taylor *et al.*, 2008f). Genetic studies suggest little movement of individuals between ocean basins (Dalebout *et al.*, 2005). Acoustic recordings of this species have been made in Cook Strait (Goetz, 2017).

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

There are two subspecies of Hector's dolphin: the South Island Hector's dolphin (*Cephalorhynchus hectori hectori*) and the Māui's dolphin (*C. hectori maui*). In general, Māui's dolphins are present on the west coast of the North Island, and South Island Hector's dolphins are present around the South Island. Over the last 40 years, numbers of both subspecies have significantly declined, largely on account of high levels of by-catch in coastal fisheries (Roberts *et al*., 2019); with other threats such as disease (i.e. toxoplasmosis) a recent focus of scientific studies. Toxoplasmosis is the primary non-fishery cause of death in Hector's and Māui's dolphins (Roberts *et al.,* 2019). The two subspecies cannot be readily differentiated at sea which complicates sightings records; however, there is no evidence to suggest that the ecology of the two subspecies is substantially different (Torres, 2012). Both subspecies have coastal distributions thought to be largely constrained within the 100 m isobath (Slooten *et al.*, 2006; Du Fresne, 2010) although Māui's dolphins have been observed out to 12 NM offshore during research surveys (DOC, 2017), South Island Hector's dolphins have been observed out to 20 NM offshore (MacKenzie & Clement, 2014), and sightings of both subspecies out to 24 NM have been reported (Du Fresne, 2010). Hector's and Māui's dolphins appear to have a strong preference for high turbidity waters. Summer densities are highest in locations closest to shore, while distribution shifts further offshore in winter (NZGOV, 2019).

Three populations are of relevance to the Operational Areas: the West Coast South Island population, East Coast South Island population and the Māui's dolphin. The West Coast South Island population extends from Milford Sound to Farewell Spit and is estimated to comprise of 5,490 individuals (MacKenzie & Clement, 2016). The East Coast South Island population extends from Farewell Spit to Nugget Point and is estimated to consist of 8,968 individuals (Mackenzie & Clement, 2016). In the top of the South Island, the main concentration of dolphins is at the eastern entrance to Cook Strait in Clifford and Cloudy Bays. Hector's dolphins are also occasionally observed in Tasman and Golden Bays.

Māui's dolphins are found only along the West Coast of the North Island, with a population stronghold between Manukau Harbour and Port Waikato (Slooten *et al.*, 2005). Their total population distribution is slightly wider, extending from Maunganui Bluff (Currey *et al*., 2012) to Taranaki (DOC, 2019a). The most recent Māui's dolphin population estimate for individuals aged one year and over is 63 individuals (95% CI = 57–75) (Baker *et al.*, 2016a). Māui's dolphins are thought to occur in very low densities in Taranaki waters (Currey *et al.*, 2012); however, recent acoustic monitoring carried out by DOC and the University of Auckland to detect the presence of Hector's and Māui's dolphins between Taranaki and Whanganui has provided further evidence that these animals are regularly present in Taranaki coastal waters and travel as far south as Tapuae (DOC, 2019a).

The possible capture of a Māui's dolphin in a commercial set net off Cape Egmont in January 2012 supported their presence in coastal Taranaki waters (MPI, 2012a), but the dolphin was disposed of at sea due to it being illegal to land the dolphin, so the actual genetic makeup could not be confirmed. South Island Hector's dolphins have been genetically identified off the west coast of the North Island (Hamner *et al.*, 2012), confirming some movement between populations.

Analysis of the stomach contents of Hector's dolphins has identified a diet consisting of a range of fish species, with red cod, ahuru, arrow squid, sprat, sole, and stargazer contributing to 77% of the total diet (Miller *et al.*, 2013). The relative importance of each prey species varies between locations, with javelinfish being of greater importance for west coast dolphins, while demersal prey are more commonly consumed in the east (Miller *et al.*, 2013).

The offshore nature of the Operational Areas serves to reduce the likelihood of encountering this threatened species during the Taranaki Checkshot Surveys. However, it is also possible that the Māui Operational Area overlaps with the transit route occasionally used by South Island Hector's dolphins as they travel to the North Island. Although, these long-range movements are thought to occur only very occasionally (see Hamner *et al.*, 2012).

Three sightings of Hector's/Māui's dolphins have been reported in the Marine Mammal AOI: two sightings were of solitary animals seen during oil and gas operations, and one sighting of ten individuals was made from the Māui-B Platform. Despite their low densities off the Taranaki coast, it is possible that both sub-species could occasionally be present in the Operational Areas. A number of stranding events have been reported inshore of the Operational Areas (i.e. Golden Bay, Tasman Bay, the outer Marlborough Sounds, Whanganui/Manawatu, Taranaki and South Waikato). It is therefore ***possible*** that Hector's/Māui's dolphins could be present in the Operational Areas.

5.2.6.3.5 Common dolphin (*Delphinus delphis*)

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

The diet of common dolphins consists of small schooling fish and squid (Rossman, 2010), with stomach content analysis in New Zealand indicating that jack mackerel, anchovy, and arrow squid are the primary prey species (Meynier *et al.*, 2008).

Common dolphins are highly social and often form large groups that consist of thousands of individuals. Individuals within these large groups will often forage co-operatively; with observed tactics including co-operative rounding-up of schooling fish into bait balls (Stockin, 2008). Common dolphins throughout New Zealand have also been observed in mixed species aggregations with Bryde's whales (Stockin, 2008).

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

Common dolphins are the most frequently encountered cetacean species in the South Taranaki Bight (Torres, 2012). Most sightings occur over summer months, but this seasonality is likely to be a reflection of observational bias (Torres, 2012). There have been a large number of common dolphin sightings within the Marine Mammal AOI, with the single largest sighting estimated at 420 individuals including calves. Stranding events are also relatively common inshore, with stranding events reported from Golden Bay, Tasman Bay, the outer Marlborough Sounds, Whanganui/Manawatu, Taranaki, and South Waikato. Based on these records, common dolphins are ***likely*** to be present throughout the Operational Areas.

5.2.6.3.6 Pilot whales (*Globicephala macrorhynchus* and *G. melas*)

There are two species of pilot whale: the long-finned pilot whale (*Globicephala melas*) and the short-finned pilot whale (*G. macrorhynchus*). While both species are present in New Zealand waters the short-finned pilot whale is less frequently encountered here as it prefers warmer subtropical habitat in deep offshore waters (Berkenbusch *et al.*, 2013). Pilot whale sightings occur in New Zealand waters during all seasons (Berkenbusch *et al.*, 2013), with sightings of pilot whales in Taranaki waters reasonably common, particularly in summer (Torres, 2012).

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

Pilot whales are highly social, often travelling in large groups of over 100 individuals (DOC, 2019b). These whales commonly strand on New Zealand coasts, with the stranding rate peaking in spring and summer (O'Callaghan *et al.*, 2001). Farewell Spit is a recognised hotspot for pilot whale mass-stranding incidents; data from 1937 to 2017 reveal that at least 30 mass-stranding events had occurred, the largest of which involved approximately 416 individual whales. Long-finned pilot whales accounted for virtually all of these stranding events with only one short-finned pilot whale mass stranding recorded in 1977. November, December and January are the most common months in which mass stranding events occur (DOC, 2010).

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

Sightings of pilot whales have been reported in the Marine Mammal AOI, including a sighting of a group of approximately 100 animals near the Māui-A Platform. Pilot whales are the most common stranding species along the coastline adjacent to the Operational Areas. A total of 77 stranding events have occurred, of which 72 have involved long-finned pilot whales, one involved short-finned pilot whales, and the remainder were unable to be identified to species level. While the majority of these stranding events have occurred in Golden Bay, stranding records also exist for Taranaki, Whanganui/Manawatu, and Tasman Bay. Based on the stranding and sighting database, it is ***likely*** that both species of pilot whales will utilise waters within the Operational Areas.

5.2.6.3.7 Dusky dolphin (*Lagenorhynchus obscurus*)

Dusky dolphins are a distributed throughout the Southern Hemisphere and are present year-round in New Zealand waters (Berkenbusch *et al.*, 2013). They are a coastal species that occur in waters above the continental slope and shelf in water depths less than 2,000 m, usually in the cooler waters of the South Island and lower North Island (Wűrsig *et al.*, 2007). Dusky dolphins tend to spend more time in offshore waters during winter months. Little is known about dusky dolphin movements, but photo-identification data confirms that individuals travel up to 1,000 km between locations around the South Island (Wűrsig *et al.*, 2007).

Dusky dolphins have been sighted within the Marine Mammal AOI while stranding events have also occurred inshore of the Operational Areas. Stranding events have mainly occurred in Tasman Bay, with Golden Bay, Whanganui/Manawatu and Taranaki also known stranding locations. On the basis of these observations, dusky dolphins are ***likely*** to be present in the Operational Areas.

5.2.6.3.8 Southern right whale dolphin (*Lissodelphis peronii*)

Southern right whale dolphins are thought to be circumpolar and common throughout their range (Jefferson *et al.,* 1994; Lipsky, 2002). Around New Zealand, the southern right whale dolphin is seldom observed at sea; however, from the occasional sightings that have been made it is apparent that these dolphins sometimes travel in large groups of up to 1,000 individuals (Baker, 1999). Despite no abundance estimates being available, this species is considered to be relatively common throughout its range (Jefferson *et al*., 1994; Lipsky, 2002).

No information is available on the acoustic repertoire of this species; however, it presumably uses echolocation to navigate and locate food as with other odontocetes.

No live sightings of this species have been reported in the Marine Mammal AOI, but eight stranding events have been reported inshore. Most of these events occurred in Golden Bay, with one each also occurring in Tasman Bay and the outer Marlborough Sounds. Based on this assessment, this species is expected to be ***occasional visitors*** to the Operational Areas.

5.2.6.3.9 Killer whale (*Orcinus orca*)

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

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

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

The diet and foraging strategy of killer whales differs based on family groups, with foraging strategy also differing based on prey type. In general, the diet of killer whales consists of four types: sharks, rays, fin-fish, and cetaceans. Rays are the most common prey type and food sharing is common amongst killer whales (Visser, 2000).

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

Killer whales have been sighted within the Marine Mammal AOI, including one sighting of 25 individuals from the Māui-B Platform. At least one calf was noted in this group. Although killer whales are rare in the stranding records, two stranding events have been reported inshore of the Operational Areas; one in Tasman Bay and one from Taranaki. Therefore, based on this assessment, killer whales are ***likely*** to utilise waters of the Operational Areas.

5.2.6.3.10 False killer whale (*Pseudorca crassidens*)

This species is widespread in deep tropical and warm temperate waters (Baird, 2009). False killer whales feed on cephalopods, fish (including tuna), and other cetaceans (Baird, 2009) and carry out foraging dives down to water depths of 500 m (Shirihai & Jarrett, 2006).

False killer whales are extremely vocal with a diverse repertoire consisting of click trains, burst-pulse sounds, and whistles. Peak frequencies of false killer whale sounds recorded from captive animals ranged from 3 to 22 kHz (Murray *et al*., 1998).

One sighting (of seven individuals) of false killer whales has been reported in the Marine Mammal AOI, and three stranding events have been reported: one each in South Waikato, Taranaki and Whanganui/Manawatū. On the basis of this assessment, this species is ***likely*** to be present in the Operational Areas, particularly over the summer months when sea surface temperatures are warmer.

5.2.6.3.11 Bottlenose dolphin (*Tursiops truncatus*)

Bottlenose dolphins occur globally in cold temperate and tropical seas, with New Zealand representing the southernmost extent of their range (DOC, 2019c). They occur in shallow coastal regions, including inshore waters, estuaries and lagoons (Berkenbusch *et al.*, 2013), and although considered a coastal species, their distribution does extend to some offshore areas (Jefferson *et al.*, 2008). Genetic evidence has confirmed that bottlenose dolphins in New Zealand represent four genetically distinct coastal populations inhabiting; Northland, Marlborough Sounds, Fiordland (Tezanos-Pinto *et al*., 2009), and Otago/Stewart Island (Brough *et al*., 2015). Photo-identification studies have revealed no matches between study sites. In addition to the inshore populations is an 'oceanic ecotype' (Baker *et al*., 2010) found around the New Zealand coast with a more offshore distribution (Zaeschmar *et al*., 2013). Torres (2012) documented two sightings of offshore bottlenose dolphins in the South Taranaki Bight with both sightings involving groups of more than 50 individuals.

Bottlenose dolphins have a varied diet consisting of a variety of fish and squid, including benthic and pelagic species. Foraging dives range from short dives in shallow habitats to depths of over 500 m (Wells & Scott, 2009).

Common bottlenose dolphins produce 'clicks' which are used for echolocation purposes (0.8 – 24 kHz) and 'whistles' which are used as a form of communication (40 – 130 kHz).

Bottlenose dolphins have been sighted in the Marine Mammal AOI and 16 stranding events have been recorded inshore. The majority of stranding events occurred in Tasman Bay; however, strandings have also occurred in Golden Bay, the outer Marlborough Sounds, Whanganui/Manawatū and Taranaki. Based on this assessment, bottlenose dolphins are ***likely*** to occur in the Operational Areas.

5.2.6.3.12 Spectacled porpoise (*Phocoena dioptrica*)

Spectacled porpoises occur only in cold temperate waters, with their distribution thought to be restricted to the circumpolar sub-Antarctic (Baker, 1999; Goodall, 2002).

No live sightings of spectacled porpoises have been made from the Marine Mammal AOI; however, one stranding event has been reported inshore. It is therefore ***possible*** that spectacled porpoises will be present within the Operational Areas from time to time.

5.2.7 Pinnipeds

There are nine species of pinniped known from New Zealand waters; however, based on the criteria in **Table 11**, only the New Zealand fur seal is discussed further as it is the only pinniped species that is likely to occur in the Operational Areas. All other species are routinely only found along the southern coast of the South Island, or in the sub-Antarctic.

5.2.7.1 New Zealand Fur Seal

The New Zealand fur seal is native to both New Zealand and Australia and is widespread around rocky coastlines on the mainland and offshore islands (Wilson, 1981).

New Zealand fur seals forage on a range of species, with the relative importance of each prey item varying by season. Arrow squid are important prey items in summer and autumn, lanternfish are taken year-round, barracouta and jack mackerel are major contributors to the summer diet, while pink cod, ahuru and octopus are important winter prey species (Harcourt *et al.*, 2002). In general, their diet shifts from a squid-dominated diet in summer and autumn, to mixed fish-dominated in winter (Harcourt *et al.*, 2002). New Zealand fur seals are among the deepest and longest-diving fur seals (Mattlin *et al.*, 1998); maximum female dives last for approximately nine minutes to depths of 312 m, while maximum dives carried out by males last for approximately 15 minutes to depths greater than 380 m (Page *et al.*, 2005). Foraging habitats vary with season and sex although inshore and deeper offshore foraging habitat is used throughout the year (Harcourt *et al.*, 2002). Females tend to forage over continental shelf waters, with males using deeper continental shelf breaks and pelagic waters (Page *et al.*, 2005). Foraging trips often last for a number of days (Page *et al.*, 2005) and GPS tagged animals have shown females to forage up to 78 km from breeding colonies (Harcourt *et al.*, 1995), foraging further offshore in winter (Harcourt *et al.*, 2002).

The breeding season for New Zealand fur seals occurs from mid-November to mid-January, with peak pupping in mid-December (Crawley & Wilson, 1976). Pups are suckled for approximately 300 days and during this time adult females alternate between foraging at sea and returning to shore to feed their young (Boren, 2005). Despite most breeding locations for this species occurring on the South Island, this species is expanding its range northwards following the cessation of commercial and subsistence hunting (Lalas & Bradshaw, 2001). There are six breeding colonies inshore of the Operational Areas: Sugar Loaf Islands (New Plymouth), Stephens Island (outer Marlborough Sounds), Tonga Island (Tasman Bay), Separation Point (Golden Bay), Pillar Point (south of Farewell Spit), and Archway Islands (south of Farewell Spit). The checkshot surveys will not affect these breeding colonies.

This species will certainly utilise the waters of the Operational Areas year-round, where concentrations at sea may occur around oil and gas facilities. These facilities provide New Zealand fur seals with offshore haul-out opportunities, opportunities to rest in the lee of the MODU or a food source with the fish that have been attracted to the MODU, as such it is highly ***likely*** they will be present in all of the Operational Areas.

5.2.8 Marine Reptiles

Nine species of marine reptile have been recorded in New Zealand waters: the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), leatherback/leathery turtle (*Dermochelys coriacea*), yellow-bellied sea snake (*Pelamis platurus*), Saint Giron's sea krait (*Laticauda colubrina*), common/blue-lipped sea krait (*L. laticaudata*) and the banded/yellow-lipped sea krait (*L. colubrina*) (DOC, 2019d; DOC, 2019e).

Due to their preference for warmer temperate and more tropical waters, most of New Zealand's marine reptiles are found off the northeast coast of the North Island (DOC, 2019f). The exception to this is the leatherback sea turtle, which has a lower thermal tolerance (DOC, 2019d). All marine reptiles in New Zealand waters are self-introduced and therefore considered native with full protection under the Wildlife Act 1953 (Godoy *et al*., 2016; DOC, 2019f).

Information is limited regarding the distribution of marine reptiles in New Zealand waters and the only assessment has been done for green turtles. Until recently, sightings of green turtles were considered to be of 'strays' that had been incidentally blown to New Zealand waters. However, Godoy *et al*. (2016) demonstrated that New Zealand is in fact a temperate intermediary habitat for this species, with individuals actively migrating to New Zealand waters with a year-round presence in northern waters. As such, it is possible that other turtle species may also actively utilise New Zealand waters although no information exists for other species. There are no records of marine reptiles breeding in New Zealand waters and it is unlikely breeding occurs here (Godoy, 2016).

Marine reptiles occasionally visit the south-western coast of the North Island, although this occurs mainly during summer months when the warmer currents push down the western side of New Zealand. Logger head turtles, leatherback turtles, olive ridley turtles, and yellow-bellied sea snakes have been observed in Taranaki waters (DOC, 2019d); however, they are ***rare visitors*** and are not routinely present.

5.2.9 Seabirds

New Zealand's waters support the most diverse collection of seabirds worldwide, with 86 species utilising New Zealand's marine environment (DOC, 2019g). New Zealand's seabird community also has the world's highest level of endemism (Forest and Bird, 2014) with near to half (35) of the species present in New Zealand classified as endemic (Taylor, 2000). 'Seabirds' covers those species that spend some part of their life cycle feeding over open marine water; this is compared to 'waders' that feed in the intertidal (Taylor, 2000). The seabirds present in New Zealand include albatross, skua, cormorants/shags, fulmars, petrels, prions, shearwaters, terns, and penguins.

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

The Taranaki Bight is visited by a number of seabirds that either pass through the region or use the area as a foraging destination. Approximately 60% of New Zealand's seabirds regularly forage more than 50 km from shore, while the remaining feed over inshore waters and are only occasionally sighted away from land (Taylor, 2000).

Various references (e.g. Scofield and Stephenson (2013); Robertson *et al.* (2017); New Zealand Birds Online (2019)) have been used to identify the seabirds that are most likely to be observed in and around the Gladstone-1, Toutouwai-1, and Māui-8 Operational Areas. Due to the low spatial extent of effects from the checkshot surveys, only seabirds have been considered in this MMIA. Similar to the marine mammals, seabirds have a large home range; therefore, the three Operational Areas have been considered jointly for this assessment. A summary of the seabirds, including their threat classifications (both the IUCN and New Zealand Threat Status), is presented in **Table 14**.

Within its Draft Coastal Plan, TRC has identified a number of seabirds as being regionally significant on account of their coastal indigenous biodiversity values (TRC, 2016). Grey-faced petrels are also considered to be 'regionally distinctive' within the Taranaki Draft Coastal Plan.

Table 14 Seabirds Potentially Present in the Operational Areas

Common Name	Scientific Name	IUCN Threat Status (www.iucnredlist.org)	NZ Threat Status (Robertson *et al.*, 2017)
Antipodean albatross*	*Diomedea antipodensis antipodensis*	Endangered	Nationally critical
Gibson's albatross	*Diomedea antipodensis gibsoni*	Endangered	Nationally critical
Salvin's mollymawk	*Thalassarche salvini*	Vulnerable	Nationally critical
Black petrel*	*Procellaria parkinsoni*	Vulnerable	Nationally vulnerable
Campbell Island mollymawk	*Thalassarche impavida*	Vulnerable	Nationally vulnerable
Flesh-footed shearwater*	*Puffinus carneipes*	Near threatened	Nationally vulnerable
Grey-headed mollymawk*	*Thalassarche chrysostoma*	Endangered	Nationally vulnerable
Hutton's shearwater	*Puffinus huttoni*	Endangered	Nationally vulnerable
Little penguin*	*Eudyptula minor*	Least concern	Declining
Sooty shearwater/Muttonbird*	*Puffinus griseus*	Near threatened	Declining
White-capped/shy mollymawk	*Thalassarche cauta steadi*	Near threatened	Declining
Northern giant petrel*	*Macronectes halli*	Least concern	Recovering
Broad-billed prion*	*Pachyptila vittata*	Least concern	Relict
Cook's petrel	*Pterodroma cookii*	Vulnerable	Relict
Fairy prion*	*Pachyptila turtur*	Least concern	Relict
Fluttering shearwater*	*Puffinus gavia*	Least concern	Relict
Grey-backed storm petrel	*Garrodia nereis*	Least concern	Relict
Mottled petrel	*Pterodroma inexpectata*	Near threatened	Relict
Northern diving petrel*	*Pelecanoides urinatrix urinatrix*	Least concern	Relict
White-faced storm petrel*	*Pelagodroma marina maoriana*	Least concern	Relict
Antarctic prion*	*Pachyptila desolata*	Least concern	Naturally uncommon
Brown skua/southern skua	*Catharacta antarctica lonnbergi*	Least concern	Naturally uncommon
Buller's mollymawk	*Thalassarche bulleri bulleri*	Near threatened	Naturally uncommon
Buller's shearwater*	*Puffinus bulleri*	Vulnerable	Naturally uncommon
Grey petrel	*Procellaria cinerea*	Near threatened	Naturally uncommon
Northern royal albatross*	*Diomedea sanfordi*	Endangered	Naturally uncommon
Snare's petrel	*Daption capense australe*	Not assessed	Naturally uncommon
Southern royal albatross*	*Diomedea epomophora*	Vulnerable	Naturally uncommon
Westland petrel	*Procellaria westlandica*	Endangered	Naturally uncommon

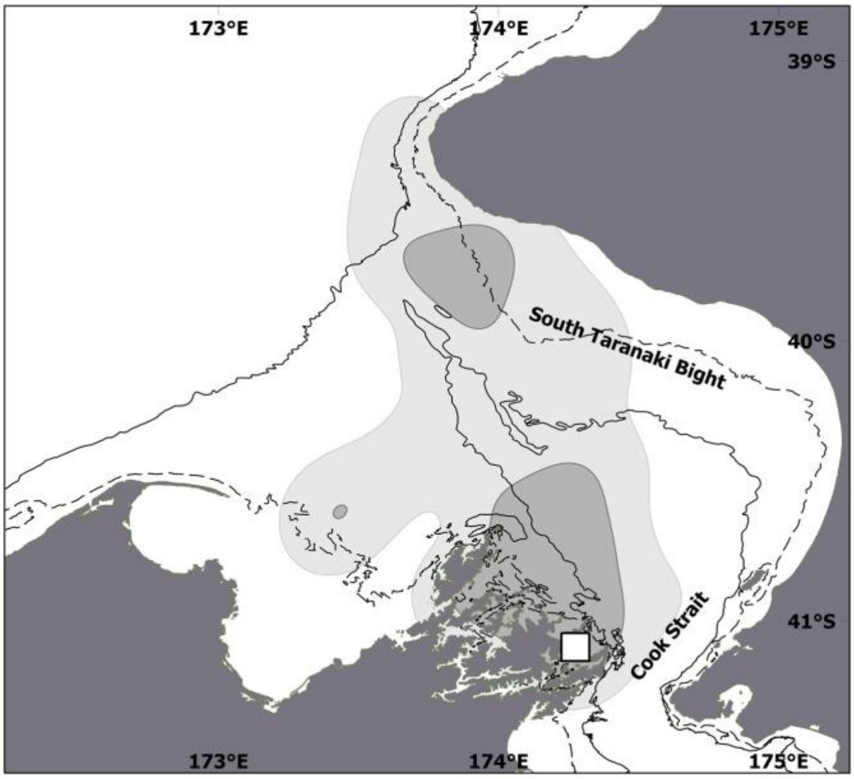
Common Name	Scientific Name	IUCN Threat Status (www.iucnredlist.org)	NZ Threat Status (Robertson *et al.*, 2017)
Arctic skua	*Stercorarius parasiticus*	Least concern	Migrant
Cape pigeon	*Daption capense capense*	Least concern	Migrant
Pomarine skua	*Coprotheres pomarinus*	Least concern	Migrant
Short-tailed shearwater	*Puffinus tenuirostris*	Least concern	Migrant
Snowy albatross	*Diomedea exulans*	Vulnerable	Migrant
Southern giant petrel	*Macronectes giganteus*	Least concern	Migrant
Wilson's storm petrel	*Oceanites oceanicus*	Least concern	Migrant
Black-browed mollymawk	*Thalassarche melanophris*	Least concern	Coloniser
Indian ocean yellow-nosed mollymawk	*Thalassarche carteri*	Endangered	Coloniser
Australasian gannet	*Morus serrator*	Least concern	Not threatened
Grey-faced petrel*	*Pterodroma gouldi*	Least concern	Not threatened
White-chinned petrel	*Procellaria aequinoctialis*	Vulnerable	Not threatened
White-headed petrel	*Pterodroma lessonii*	Least concern	Not threatened

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

5.2.9.1 Little Penguin Foraging Area

Historically little penguins (*Eudyptula minor*) were thought to forage within 30 km of their nest during the chick-rearing stage (Hoskins *et al.*, 2008; Agnew, 2014; Pelletier *et al.*, 2014), with unusually long foraging trips of up to 118 km recorded only for the closely related Australian little blue penguins (*Eudyptula novaehollandiae*) in the eastern Great Australian Bight (Wiebkin *et al.*, 2005). Recent GPS tracking studies carried out by Poupart *et al.* (2017) have suggested that little penguins in New Zealand waters are capable of, and routinely carry out, large foraging trips of up to 214 km from breeding colonies. Tracked penguins from colonies within the Marlborough Sounds frequently utilise South Taranaki Bight waters as foraging grounds (**Figure 13**). Long-distance foraging trips were found to be particularly important during the egg-incubation stage (Poupart *et al.*, 2017); eggs are typically laid in July to November with incubation lasting up to 36 days (NZ Birds Online, 2019). Following the incubation period, chicks are fed by both parents who carry out foraging trips closer to the nesting site (Poupart *et al.*, 2017). Based on the findings of Poupart *et al.* (2017) there is potential for little blue penguins nesting along the Taranaki coastline and within the Marlborough Sounds to utilise the waters of the Operational Areas, particularly within the Māui-8 Operational Area.

Figure 13 Foraging Areas of Little Penguins from Motuara Island (Marlborough Sounds) During Incubation



Note: Light grey represents the home range. Dark grey represents the focal area. Study colony is shown by the white square. The dashed line represents the 50 m bathymetric contour and the solid line is 100 m.

Source: Poupart *et al*., 2017

5.3 Cultural Environment

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

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

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

Due to the restricted spatial extent of effects associated with the Taranaki Checkshot Surveys and their considerable distance from the coastline, a detailed and exhaustive list of wāhi tapu and mahinga kai sites is not considered necessary within this MMIA.

5.3.1 Customary Fishing and Iwi Fisheries Interests

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

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

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

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

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

There are three types of customary fishing rights recognised under the legislation: rohe moana Mātaitai and Taiapure. As shown in **Figure 14**, all rohe moana, Mātaitai and Taiapure are located well inshore or outside of the Operational Areas and will not be affected by the checkshot surveys. The closest Mātaitai and Taiapure are located in the Waikato and Tasman regions, and as such will not be affected by any activities associated with the checkshot surveys.

5.3.1.1 Rohe Moana

Rohe moana may be established under the Fisheries (Kaimoana Customary Fishing) Regulations 1998 as recognised traditional food gathering areas for which Kaitiaki (customary managers) may be appointed to manage kaimoana collection in accordance with traditional Māori principles. They allow for the establishment of management controls, the issuing of permits for customary take, the enforcement of penalties for management breaches, and for restrictions to be established over fisheries areas to prevent stock depletion or overexploitation. The intention of a rohe moana is for better provision for the recognition of Rangatiratanga (sovereignty) and of the right secured in relation to fisheries by Article II of the Treaty of Waitangi. The legally recognised boundaries of each rohe moana typically mirror the landward boundary of the CMA.

The closest rohe moana to the Operational Areas are as follows (Note: these rohe moana are inshore of the Operational Areas):

- Ngāti kinohaku
- Ngāti Te Kanawa
- Ngāti Peehi Rohe Moana
- Ngāti Haumia Rohe Moana; and
- Titahi-Ngaruahine Rohe Moana.

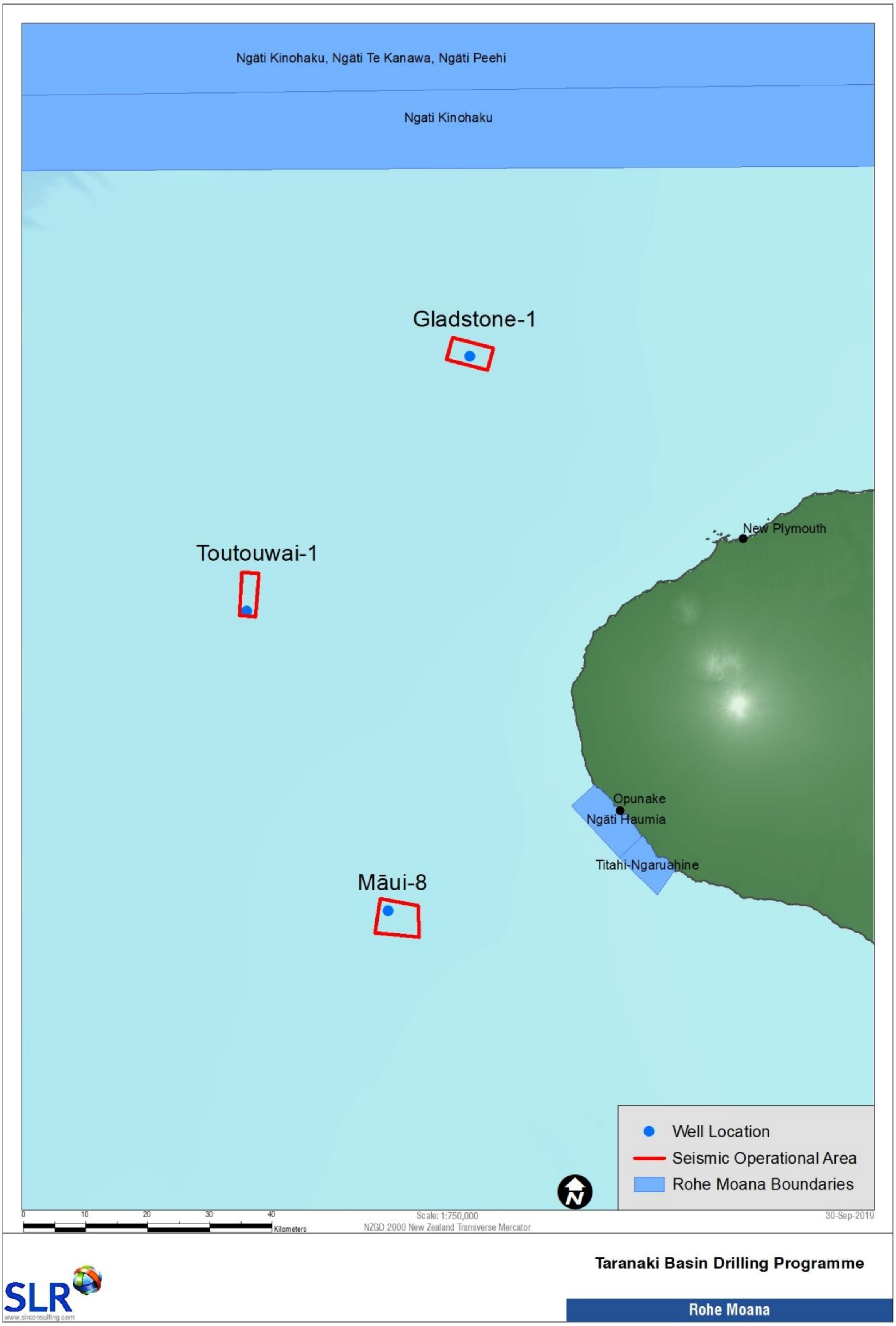
An additional rohe moana, the 'Deepwater Customary Pataka' has been proposed. This pataka (food supply) represents an agreement between 16 iwi groups, Sealord Fishing and Te Ohu Kaimoana to facilitate customary fishing in deeper waters of the South Taranaki Bight. Within this rohe moana the Sealord Fishing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

5.3.1.2 Te Taihauāuru Forum

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

In addition to the Te Taihauāuru Iwi Forum Fisheries Plan is the 'Rangitaane (North Island) Iwi Fisheries Plan'. This plan was one of the first Iwi Fisheries Plans to be developed in New Zealand and was a joint collaboration between Wairarapa, Manawatu, and Tamaki Nui a Rua (Rangitāne). Like the Forum Fisheries Plan, the Rangitāne Iwi Fisheries Plan outlines a number of objectives for the development of commercial fisheries and the management of habitats and species protection (Rangitāne o Wairarapa Inc, 2019).

Figure 14 Rohe Moana of Relevance to the Operational Areas



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

The Marine and Coastal Area (Takutai Moana) Act 2011 acknowledges the importance of the marine and coastal area to all New Zealanders while providing for the recognition of the customary rights of iwi, hapū and whānau in the CMA. Iwi, hapū or whānau groups may be granted recognition of two types of customary interest under the Marine and Coastal Area Act: Customary Marine Title and Protected Customary Rights. The recognition that these two types of customary interest provide were summarised by the Department of Justice (Te Arawhiti, 2019), as outlined below.

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

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

Protected Customary Rights may be granted within the CMA to allow for customary activities such as the collection of hāngi stones or launching of waka.

If a group has a Protected Customary Right recognised, they do not need Resource Consent to carry out that activity and local authorities can’t grant Resource Consents for other activities that would have an adverse effect on the Protected Customary Right.

Due to the restricted spatial range of effects arising from activities associated with the checkshot surveys, the coastal nature (i.e. within the CMA) of Customary Marine Title and Protected Customary Rights claims, and the fact that all of the applications are still to be approved, these proposed application areas have not been considered any further within this MMIA.

5.4 Socio-Economic Environment

This section outlines the socio-economic environment within and in close proximity to the Gladstone-1, Toutouwai-1 and Māui-8 Operational Areas. This section covers fisheries (recreational and commercial), shipping, oil and gas activities, tourism and marine scientific research.

5.4.1 Fisheries

Fishing in New Zealand's coastal and EEZ waters can be spilt into three main parts:

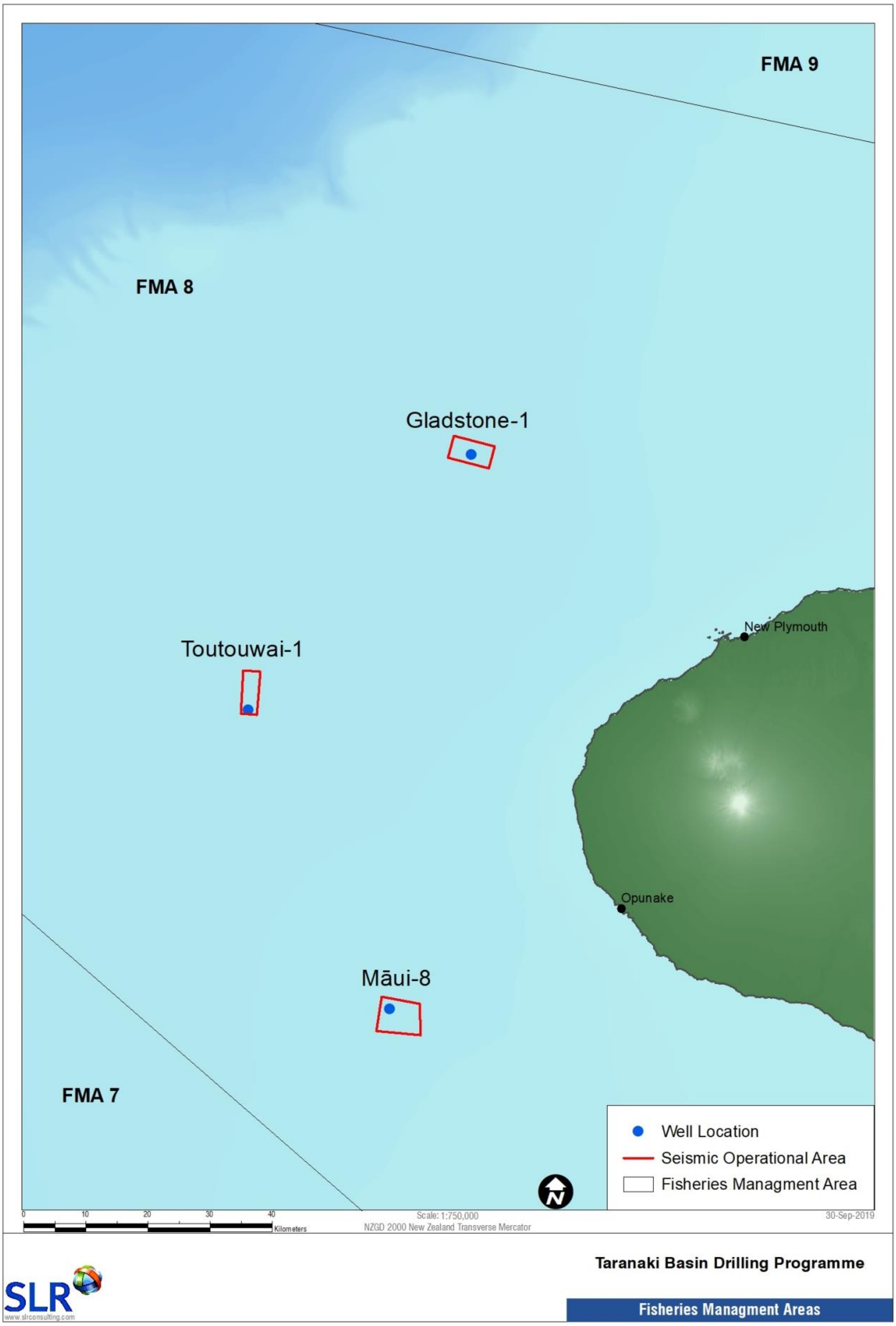
- Commercial fishing;
- Traditional/customary fishing; and
- Recreational fishing.

Ten Fisheries Management Areas (**FMA**) have been implemented within New Zealand waters in order to manage the Quota Management System (**QMS**). The QMS is the primary management tool to allow commercial utilisation of New Zealand's fisheries resources and ensure their sustainability for the future and is currently regulated by Fisheries New Zealand (**FNZ**). Over 1,000 fish species occur in New Zealand waters (Te Ara, 2019f), with the QMS and Annual Catch Entitlements providing for the commercial utilisation and sustainable catch of 96 of these species. The Annual Catch Entitlements take into account commercial catch from previous seasons and the recreational and customary catches and is used to determine each year's Total Allowable Commercial Catch which is split amongst the quota owners. Species managed under the QMS are divided into separate stocks, with each stock managed independently within each FMA. The Gladstone-1, Toutouwai-1, and Māui-8 Operational Areas all lay within FMA 8 (Central) (**Figure 15**).

FMA 8 extends along the Taranaki and Whanganui coastline, where the exposed coastline is subject to westerly winds and southwest swells, which can often result in rough seas and limit the number of fishable days. Despite the exposed nature of the coastline, the area is considered to have a valuable recreational, customary and inshore commercial and offshore trawler fishery. FNZ has rated the customary and recreational significance and the environmental importance of this area and considers that it is high (FNZ, 2019).

Recreational and commercial fisheries within FMA 8 are discussed in **Sections 5.4.1.1** and **5.4.1.2** respectively, while customary fisheries are discussed in **Section 5.3.1**.

Figure 15 Fisheries Management Areas of Relevance to the Gladstone-1, Toutouwai-1, and Māui-8 Operational Areas



5.4.1.1 Recreational Fisheries

Recreational fishing is one of the most popular pastimes in New Zealand; a 2001 survey of the most popular leisure activities placed fishing (marine and freshwater combined) as the fifth most popular recreational activity after walking, gardening, swimming, and exercising (Te Ara, 2019g). The National Research Bureau Ltd recently conducted a nationwide recreational fishing survey on behalf of the Ministry for Primary Industries. Although there has been a decline since a 2011/12 fishing survey in the level of the population that fish, the number of fishers was estimated to be approximately 348,000 New Zealanders (Wynne-Jones *et al*., 2019). The most frequent method of fishing is by rod or line from a trailer boat, followed by fishing with a rod or line from land. The most commonly harvested finfish species (determined by weight) in FMA 8 was blue cod, kahawai, pilchard, red gurnard, snapper and tarakihi (Wynne-Jones *et al*., 2019).

While recreational fishing occurs widely off the Taranaki coast, the significant distance from shore of the Gladstone-1, Toutouwai-1 and Māui-8 Operational Areas means that the number of recreational fishing vessels that might venture close to the Operational Areas would be minimal. Some deepwater recreational demersal fishing for hapuku, bass, gemfish and bluenose does occur out at the edge of the continental shelf off Taranaki.

Recreational game fishing for pelagic species occurs widely in offshore Taranaki waters, with fishers targeting striped marlin, albacore, bigeye and skipjack tuna, mahi-mahi, kingfish and mako sharks. The vast majority of the game-fishing effort occurs within 30 km of the coast, but as technology has improved and recreational vessels have gotten larger, better equipped and more reliable, distances offshore have increased. On this basis, there is potential that recreational fishing vessels from Port Taranaki may venture near the Operational Areas.

5.4.1.2 Commercial Fisheries

Commercial fisheries within the offshore waters of FMA 8 consist primarily of a midwater trawl fishery targeting blue mackerel and jack mackerel, with a number of other species taken as by-catch. In evidence supplied for Shell’s 2017 Māui Marine Consent hearing, Gibbs (2017) stated that species associated with the mackerel mid-water trawl fishery such as barracouta and frostfish are also occasionally targeted.

Fishing within the North Island’s west coast mackerel fishery occurs year-round, although most of the catch is taken in two distinct periods: October – January and April – July. The number of vessels fishing the mackerel fishery is largely dependent on the availability of the fleet (vessels also fish elsewhere in the EEZ targeting southern blue whiting, squid and hoki), not the availability of mackerel (Gibbs, 2017).

Current regulations prohibit set-netting out to 7 NM offshore from Waiwhakaiho River (north of New Plymouth) to Hawera, unless an FNZ fisheries observer is onboard (MacDiarmid & Ballara, 2016). Commercial fishing is also prohibited within the 500 m safety zones surrounding the MPA, MPB, Maari and Kupe Platforms, the FPSO ‘*Umuroa*’ and ‘*Raroa*’ and the cable protection areas that run along the length of the Māui and Kupe pipelines (Gibbs, 2013). The large trawlers fishing for species such as barracouta and jack mackerel are also prohibited from fishing within 20 NM of the coastline.

Details on commercial finfish catch for each Operational Area, based on catch data obtained from FNZ are discussed below.

5.4.1.2.1 Gladstone-1 Operational Area

FNZ provided data for the commercial fishing effort undertaken within a 100 km^2 (10 km x 10 km box) area around the Gladstone-1 Operational Area taken over five fishing years (i.e. 1 October 2013 – 30 September 2017). Gladstone-1 is located in an area of significant commercial fishing effort, with between 48 and 58 'fishing events' taking place within the defined area (**Figure 16**).

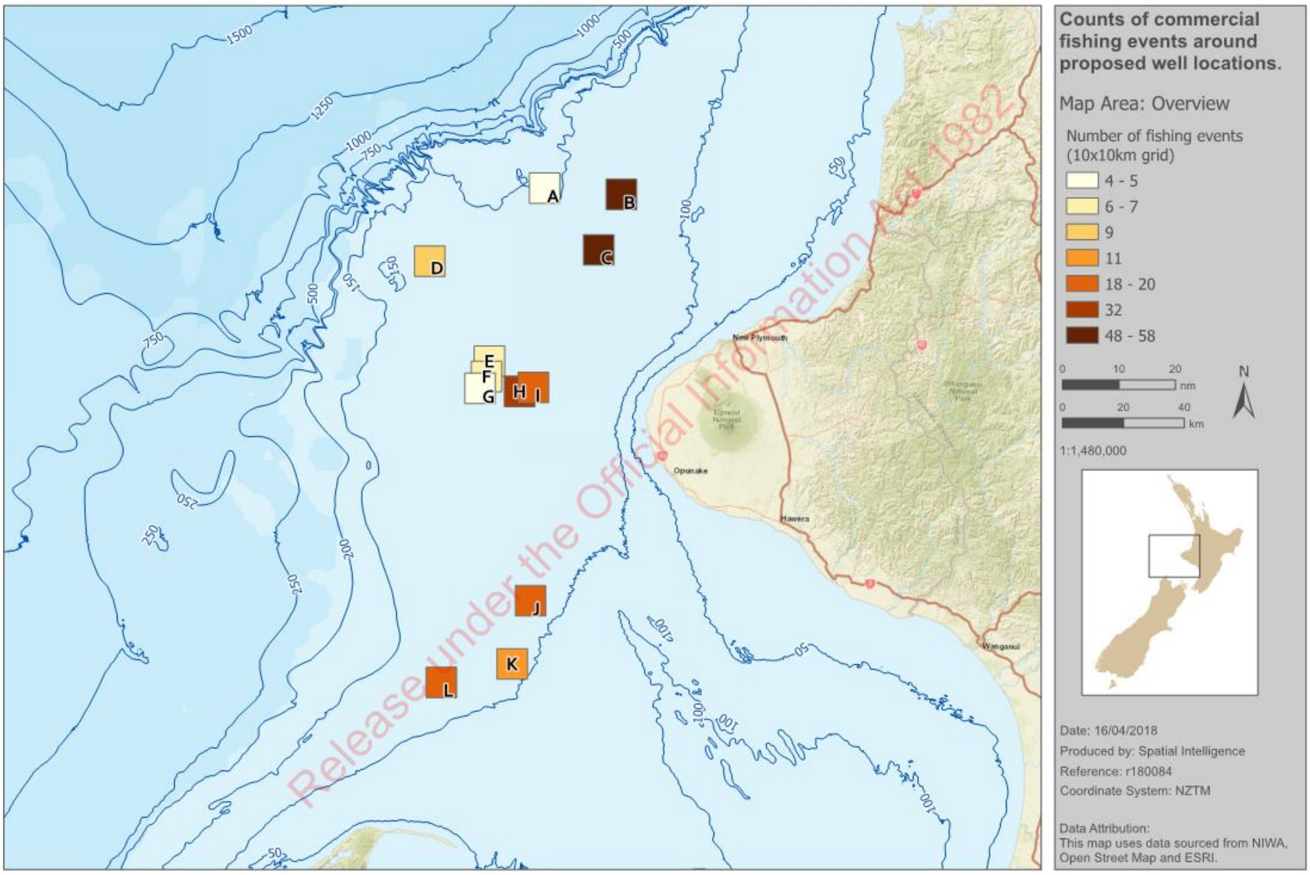
Commercial fishing events around the Gladstone-1 Operational Area targeted albacore tuna, john dory, jack mackerel, school shark and tarakihi, with a number of other species taken as by-catch. Jack mackerel catch was the highest for all species caught within this area. Estimated catch total for each species caught within the Gladstone-1 area are provided in **Table 15**.

Table 15 Commercial Fisheries Catch taken around Gladstone-1

Species	Green weight (kg)	Species	Green weight (kg)
Albacore tuna	20	School shark	870
Barracouta	12,870	Snapper	302
Frostfish	68,220	Spiny dogfish	390
Jack mackerel	902,170	Tarakihi	1,110
Northern spiny dogfish	85		

Source: FNZ, 2018

Figure 16 Commercial Fishing Events around Gladstone-1 (Box 'C') and Toutouwai-1 (Box 'F')



Source: FNZ, 2018

5.4.1.2.2 Toutouwai-1 Operational Area

Toutouwai-1 is located in an area of relatively low commercial fishing effort, with between six and seven fishing events taking place within the defined area (**Figure 16**).

Commercial fishing events around Toutouwai-1 targeted jack mackerel, school shark and warehou, with jack mackerel making up the majority of take from this area. Total catch for each species commercially caught around the Toutouwai-1 site is provided in **Table 16**.

Table 16 Commercial Fisheries Catch taken around Toutouwai-1

Species	Greenweight (kg)	Species	Greenweight (kg)
Barracouta	200	Northern spiny dogfish	530
Frostfish	4,300	School shark	200
Gurnard	30	Snapper	5
Hapuku and Bass	50	Spiny dogfish	500
John dory	15	Warehou	600
Jack mackerel	80,385		

Source: FNZ, 2018

5.4.1.2.3 Māui-8 Operational Area

Within the last five calendar years (i.e. start of 2014 – end of 2018), 23 fishing events have occurred within the wider Māui Field, with fishing events targeting blue mackerel and jack mackerel. Total estimated greenweight of blue and jack mackerel caught within the Māui Field was estimated to be 405.67 tonnes (FNZ, 2019a). By-catch caught within the blue mackerel and jack mackerel fishery around the Māui Field is provided in **Table 17**.

Table 17 By-catch of Finfish Caught at the Māui Field between 2014 and 2018

Species	Greenweight (kg)	Species	Greenweight (kg)
Sunfish	200	Jack mackerel	5,000
Barracouta	18,640	Pilchard	2,150
Blue mackerel	300	Thresher shark	100
Frostfish	9,150		

Source: FNZ, 2019a

5.4.2 Shipping

5.4.2.1 Ports and Harbours

Thirteen major commercial ports and harbours exist around New Zealand's coastline and can be split into three types: major ports, river ports and breakwater ports. Several of these ports are of relevance to the three Operational Areas including Port Nelson, CentrePort Wellington, Port Marlborough at Picton and Port Taranaki, all of which cater for a large variety of shipping from small fishing vessels to large tanker, container and bulk cargo vessels. These ports are shown in **Figure 17**.

5.4.2.2 Commercial Shipping

MNZ recommend commercial vessels should stay a minimum of 5 NM off the mainland, any charted points of danger, or any offshore islands. There are no dedicated shipping channels into/out of or between the major and/or minor ports of New Zealand, and as a result vessels travelling to/from or between ports will generally take the most direct or shortest route possible, providing it is safe to do so. Shipping density of vessels transiting the Taranaki Bight around the Gladstone-1, Toutouwai-1, and Māui-8 Operational Areas is shown in **Figure 17**. Traffic levels are lower in winter on account of the lower density of fishing vessels in winter compared to summer (McPherson *et al.,* 2019).

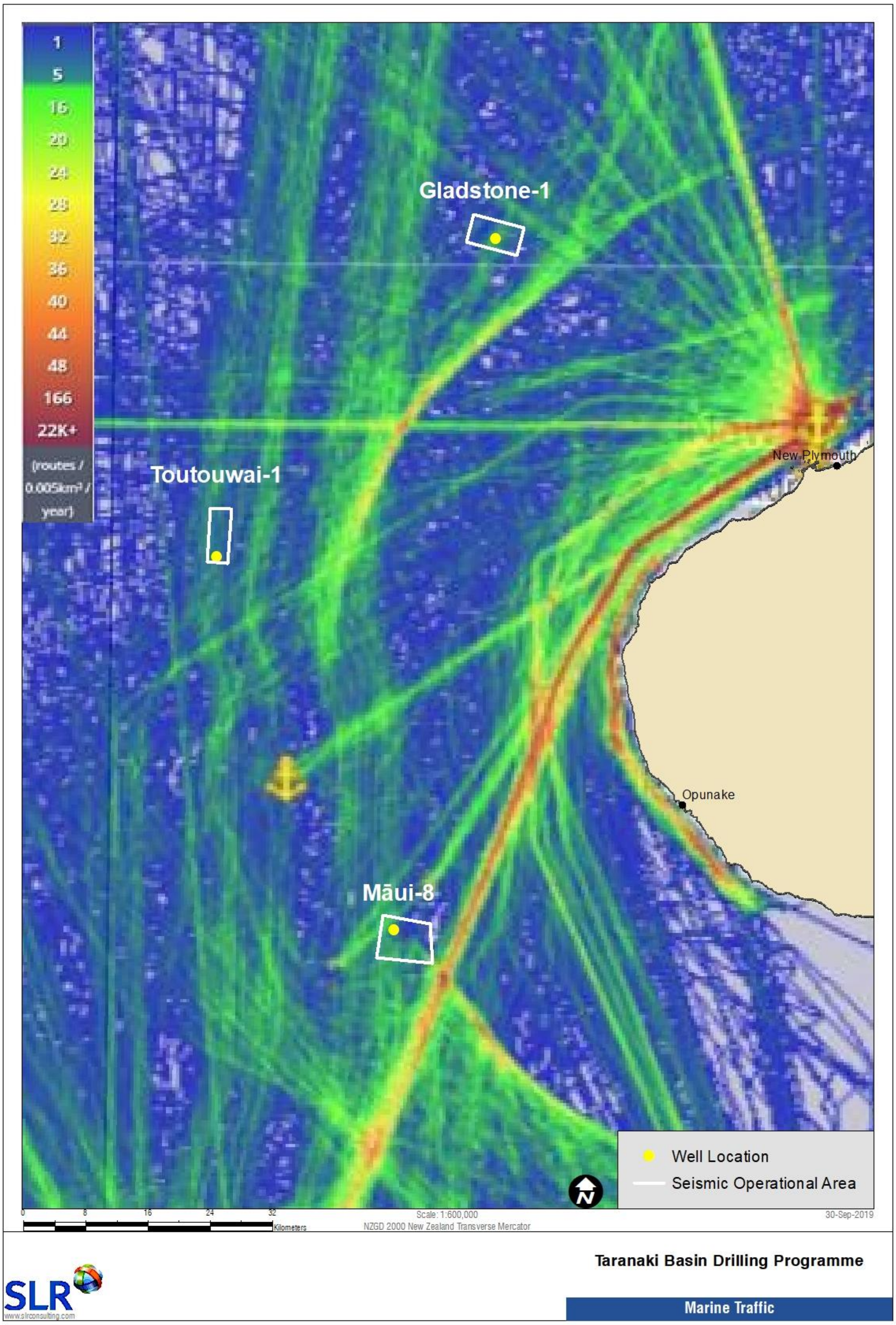
There is some possibility that vessels coming/going to/from foreign ports could pass near the Operational Areas. Guidance within the New Zealand Nautical Almanac recommends that vessels operating in the vicinity of production platforms and exploration rigs maintain an adequate safe margin of distance, and where there is sufficient sea room, vessels should keep at least 5 NM clear of any MODU and/or installation.

A precautionary area was established in the offshore Taranaki area by the International Maritime Organisation in 2007 (**Figure 18**). All ships passing through this area must navigate with particular caution in order to reduce the risk of a maritime casualty and the possible resulting marine pollution, given the high level of offshore petroleum activity within this area. The precautionary area is a standing notice in the Notice to Mariners issued by LINZ each year in the New Zealand Nautical Almanac. The almanac lists the navigation hazards within this precautionary area as the Pohokura, Māui, Maari, Tui and Kupe fields. The Māui-8 Operational Area lies within the Precautionary Area, while the Gladstone-1 and Toutouwai-1 Operational Areas are to the north of this designated area. Maritime Chart NZ48 – 'Western Approaches to Cook Strait' states "*All ships should navigate with particular caution in order to reduce the risk of marine pollution in the precautionary area*".

A 500 m Non-Interference Zone will be in place around the MODU in accordance with the Crown Minerals Amendment Act, 2013. This prevents any vessels from entering the Non-Interference Zone without reasonable excuse, or they will face prosecution. The details of the Non-Interference Zone around the MODU will be published in the New Zealand Notice to Mariners.

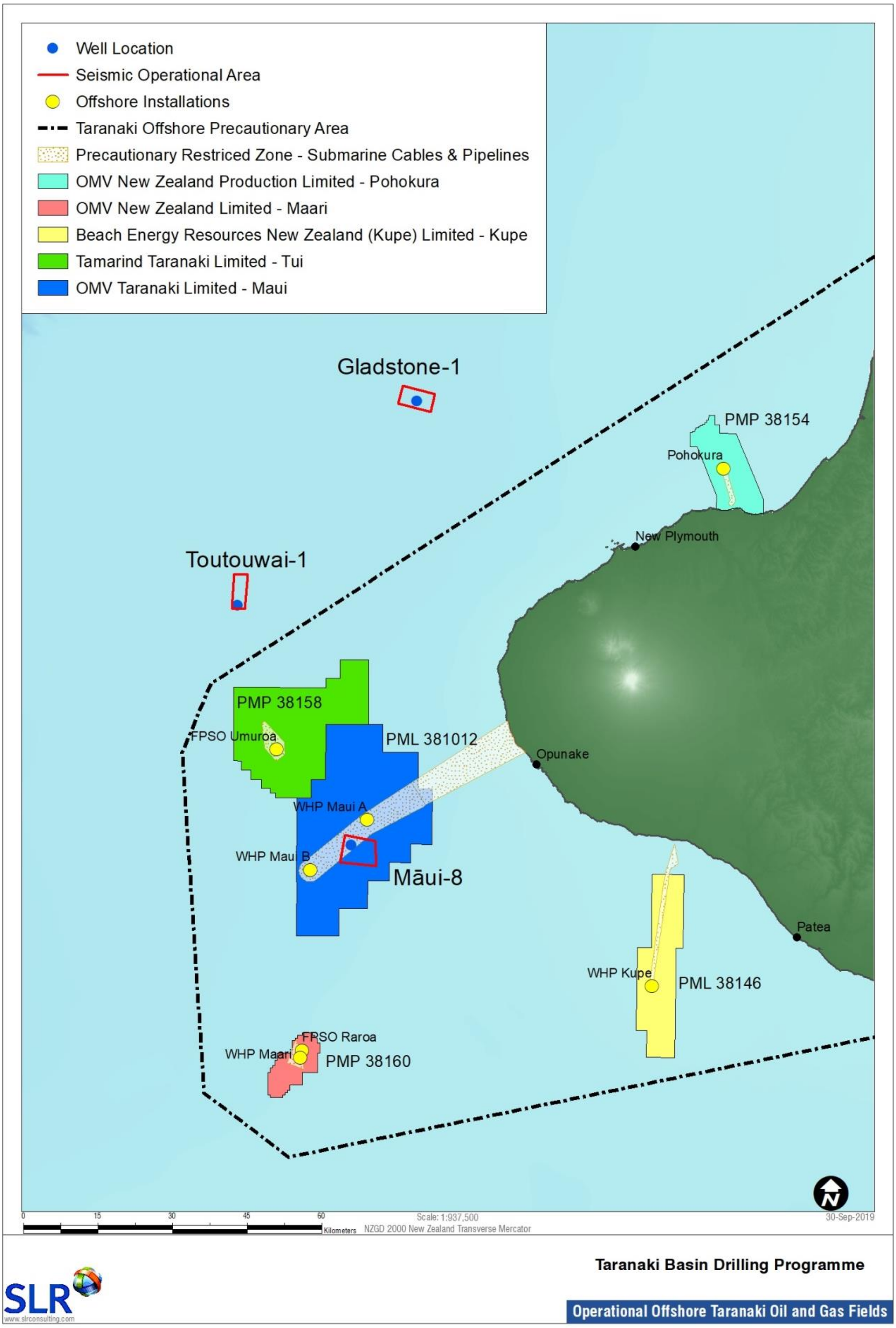
In 2000 the International Maritime Organisation required ships to be fitted with Automated Identification Systems (**AIS**) as a primary collision-avoidance tool. The MODU and any support vessels will have AIS instruments fitted and operational that broadcast key information (e.g. vessel position, identity, type, speed, course, etc.) at regular intervals, which can be received by all other vessels, installations and onshore monitoring facilities fitted with AIS receivers.

Figure 17 Shipping Density of the Taranaki Bight (2016 – 2017)



Source: Density tracks taken from www.marinetraffic.com.

Figure 18 Taranaki Offshore Precautionary Area and Operational Oil and Gas Fields in Relation to the Operational Areas


Well Location
Seismic Operational Area
Offshore Installations
Taranaki Offshore Precautionary Area
Precautionary Restriced Zone - Submarine Cables & Pipelines
OMV New Zealand Production Limited - Pohokura
OMV New Zealand Limited - Maari
Beach Energy Resources New Zealand (Kupe) Limited - Kupe
Tamarind Taranaki Limited - Tui
OMV Taranaki Limited - Maui
Gladstone-1
PMP 38154
Pohokura
New Plymouth
Toutouwai-1
PMP 38158
FPSO Umuroa
PML 381012
Opunake
WHP Maui A
WHP Maui B
Māui-8
Patea
WHP Kupe
PML 38146
FPSO Raroa
WHP Maari
PMP 38160
0 15 30 45 60
Kilometers
Scale: 1:937,500
NZGD 2000 New Zealand Transverse Mercator
30-Sep-2019
Taranaki Basin Drilling Programme
Operational Offshore Taranaki Oil and Gas Fields

5.4.3 Oil and Gas Activities

Exploration for hydrocarbons has occurred off the coast of Taranaki since the 1960s, with production of gas, condensate, oil and associated products since 1979. The Taranaki region is the centre of New Zealand's oil, gas and petrochemical industries, and with the significant economic input the industry and associated support industries contribute, oil and gas is of major importance to the New Zealand economy. Oil and gas facilities in the Taranaki region produce crude oil, condensate, naphtha, natural gas, liquefied petroleum gas and compressed natural gas, as well as the petrochemical products methanol and urea.

Current producing fields in the offshore Taranaki area are shown in (**Figure 18**) and include the Maari, Māui, Tui, Kupe and Pohokura fields. Structures at these fields include a platform at Pohokura, the FPSO '*Umuroa*' at Tui, two platforms (Māui-A and Māui-B) at the Māui Field, and the Kupe platform with associated pipelines at the Kupe Field. OMV New Zealand's Maari Field is supported by the FPSO '*Raroa*' and the Maari Well Head Platform 'Tiro Tiro Moana'.

Under the Submarine Cables and Pipelines Protection Act 1996 various protected areas have been established around New Zealand by Order in Council. These areas typically ban all anchoring and most types of fishing to prevent cable and pipeline damage. Some of the areas established under this Act have been defined as a Marine Protected Area as they are considered by DOC to have strong enough positive effects of protecting local species and habitat.

As shown in **Figure 18**, there are no existing oil and gas activities around the Gladstone-1 Operational Area. The closest existing oil and gas activities to the Toutouwai-1 Operational Area are the Tui Field and FPSO *Umuroa*. The Māui-8 Operational Area is located within the Māui Field, which includes the Māui-A and Māui-B Platforms and associated subsea infrastructure. All structures associated with the Māui Field are protected under the Submarine Cables and Pipelines Protection Order 2009.

5.4.4 Marine Scientific Research

A number of scientific and conservation organisations conduct research within and surrounding the three Operational Areas. DOC, the Ministry for Primary Industries, NIWA, Universities (e.g. Victoria University, Oregon State etc.), SLR, and the Cawthron Institute, along with some local Iwi and community groups (e.g. those associated with the South Taranaki Reef Life Project) all conduct research and/or monitoring work in various locations within, near, or in the coastal vicinity of, the three Operational Areas.

Substantial numbers of water column and seabed surveys have been conducted for baseline assessments and ongoing compliance monitoring in the South Taranaki Bight around exploration wells and existing oil and gas production facilities as required under their Marine Consent conditions. A further significant amount of work investigating the benthic and water column environments in the South Taranaki Bight was undertaken as part of the Trans-Tasman Resources Limited Marine Consent application.

The marine research carried out along the Taranaki coasts and within the North and South Taranaki Bight further enhances the knowledge pool about the water column and benthic environments that exist in the region. The gathered information also allows assessments of how the environments react to and recover from various natural and anthropogenic impacts. For example, the pre- and post-drill monitoring surveys carried out around previous exploration wells in Taranaki by OMV (i.e. Manaia-2, Matuku-1, Whio-1) have provided significant detail about the impacts of drilling activities on the benthic macrofauna communities that exist in the region and how these communities respond and recover with time.

6 Potential Environmental Effects and Mitigation Measures

This section presents an overview of the potential environmental effects that may arise from the operation of the checkshot surveys within the Gladstone-1, Toutouwai-1 and Māui-8 Operational Areas. Effects could occur under normal operating situations (i.e. planned activities), or during an accidental incident (i.e. unplanned events). Proposed mitigation measures are provided throughout the relevant sections.

6.1 Environmental Risk Assessment Methodology

The following steps were followed in order to assess the significance of potential effects from the checkshot surveys:

- Identification of the sources of potential effects (both positive and negative);
- Description of potential effects;
- Identification of the key potential environmental receptors and their sensitivity to potential effects;
- Description of mitigation measures that will be employed to minimise potential effects; and
- Assessment of the significance of any residual effects. This assessment considers the likelihood and magnitude of any residual effect in relation to the sensitivity of each environmental receptor. The 'Assessment of Significance' criteria used for residual effects are provided in **Table 18**.

Table 18 Assessment of Significance of Residual Effects

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

6.2 Planned Activities

6.2.1 Physical Presence of MODU and Support Vessel

Operation of the acoustic source will be carried out onboard the MODU used to drill the wells associated with the Taranaki and Māui EAD Programmes. A support vessel will also be present around the MODU upon which the PAM Operators will be based to avoid the noise interference on the MODU. Two MMOs will be on the MODU for the marine mammal observations during daylight hours. The support vessel with the active PAM system will be circling the MODU at a radius of approximately 1 km to acoustically detect any marine mammals.

Potential effects arising from the physical presence of the MODU and support vessel have been addressed within the Marine Consent applications associated with the Taranaki and Māui EAD Programmes but have been summarised for completeness.

6.2.1.1 Potential Effects on Marine Mammals

In the presence of vessels marine mammals tend to exhibit two stereotypical behaviours: avoidance or attraction (Wűrsig *et al*., 1998). These responses can affect the animal's energy expenditure when they become distracted from engaging in natural behaviours (e.g. feeding, resting, socialising etc.). Avoidance responses are more frequently documented than attraction responses, with avoidance most commonly leading to animals becoming temporarily displaced from an area (Wűrsig *et al*., 1998). Displacement is of particular concern when changes occur frequently over a prolonged period and/or when they affect critical behaviours (i.e. feeding, breeding and resting). While the physical presence of the MODU and support vessel has the potential to cause some changes in marine mammal behaviours, the short duration and stationary nature of the checkshot surveys means the disturbance would be temporary and localised.

'Ship strike' refers to the collision between a vessel and animal and has been recognised as an increasing global conservation concern for marine mammals (IWC, 2014). The potential for ship strike is present in all areas where marine mammals and vessel traffic overlap. Due to the checkshot surveys being undertaken from the stationary MODU, and the support vessel operating nearby at very slow speeds or stationary, the risk of vessel strike is very low.

Overall, it is considered that the residual risk to marine mammals arising from the physical presence of the MODU and support vessel during the Taranaki Checkshot Surveys is **negligible**.

6.2.1.2 Potential Effects on Seabirds

Seabird interactions with all vessel types are relatively common in both coastal and open waters. Although most interactions are harmless or even positive (e.g. the provision of perching opportunities), some can be detrimental and may cause injury or death (e.g. bird strike and/or entanglement with vessel structures). Seabirds have been shown to respond to vessels by avoidance of heavily used areas and disruption of feeding behaviours (Schwemmer *et al.*, 2011; Velando & Munilla, 2011).

The potential effects of the MODU and support vessel on seabirds were covered in specific detail in the Marine Consent Application documents, and the short-term, largely stationary operations during the Taranaki Checkshot Surveys provides no greater risk for collision/entanglement than that assessed in the Taranaki and Māui EAD Marine Consent applications. Overall, significance of the residual impact associated with the physical presence of the MODU and support vessel and the associated effects on seabirds is considered to be **negligible**.

6.2.1.3 Potential Effects on Other Marine Users

The short duration and stationary, highly localised nature of the Taranaki Checkshot Survey means there is unlikely to be a hazard of collision and the temporary displacement of other marine users from the Operational Areas would not increase above the already consented presence for the wider Taranaki and Māui EAD Programmes.

Other commercial users in the offshore Taranaki area will be notified of presence of the MODU and support vessel through notices to mariners and coastal navigation warnings and the fact that the MODU will have been on location for 25-50 days prior to any checkshot surveys commence. In addition, all vessels involved in the checkshot surveys will comply with COLREGS (e.g. radio contact, day shapes, navigation lights, etc.). With these mitigation measures and management practices in place, the residual environmental risk to other marine traffic around the well areas due to the presence of the MODU and support vessel during the Taranaki Checkshot Surveys is considered to be **negligible**.

6.2.2 Acoustic Disturbance to the Marine Environment

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

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

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

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

When considering the effects of the Taranaki Checkshot Surveys on marine fauna, caution must be taken in interpretation of results as most studies have focused on vessel-based 2D and 3D surveys. During the Taranaki Checkshot Surveys the small volume acoustic source is stationary, and relatively few shots are fired over a short survey period (i.e. hours). In comparison, most 2D and 3D seismic survey programmes typically run continuously for multiple days to months, and utilise a large acoustic source fired approximately every 10 seconds.

The Code of Conduct was developed specifically to minimise the potential behavioural and physiological effects on marine mammals of acoustic disturbance from seismic surveys. Compliance with the Code of Conduct represents the primary way in which the potential effects of acoustic disturbance during the checkshot surveys will be managed. STLM uses input parameters specific to the source array, and Operational Area-specific bathymetry and geological data. The Code of Conduct required STLM for any Level 1 survey that will occur within an Area of Ecological Importance (**Figure 4**). Although the Gladstone-1 Operational Area lies outside of the Area of Ecological Importance, STLM for this Operational Area has been included. A summary of the STLM results is presented in **Section 6.2.2.1**, while the full STLM report is provided in **Appendix A**.

6.2.2.1 Sound Transmission Loss Modelling

SLR undertook STLM to predict received SELs from the checkshot surveys within the Gladstone-1, Toutouwai-1 and Māui-8 Operational Areas to assess for compliance with the mitigation zones in the Code of Conduct. The modelling of the STLM addresses the horizontal and vertical directionality of the acoustic array and takes into consideration the water depth and substrate within each Operational Area. The results of the modelling report are summarised below, with the complete report provided in **Appendix A**.

A single source location (i.e. the well location) was selected at each Operational Area for the purpose of short-range modelling. The short-range modelling locations represent each proposed well location within the Operational Areas, as shown in **Figure 1**. Short-range modelling predicts the received SELs over a range of a few kilometres from the source location, in order to assess whether the proposed survey complies with the regulatory mitigation zones SEL requirements defined within the Code of Conduct. The STLM short-range modelling results for each Operational Area are provided below.

The Continental Shelf of New Zealand is mainly covered with land-derived sand, gravel and mud sediments which have been predominantly introduced by riverine inputs. In order to predict the highest SELs possible during each checkshot survey, the most reflective (i.e. worst-case) substrate was used for the modelling, resulting in the use of a sandy seabed. As the actual commencement for the Taranaki Checkshot Surveys was not known at the commencement of the STLM, and the fact that the survey will span a couple of seasons, a winter sound speed profile was selected as this season favours the propagation of sound (i.e. it represents the worst-case season). The water depths at each planned well location were used for modelling purposes.

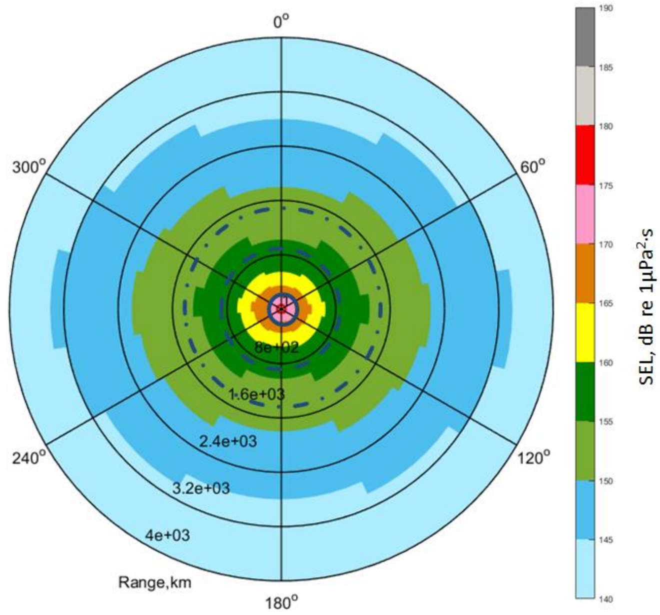
6.2.2.1.1 Gladstone-1 Modelling Results

The results of the short-range modelling at Gladstone-1 are depicted in **Figure 19** and **Figure 20**. **Figure 19** depicts the maximum received SELs across the water column as a function of azimuth and range from the centre of the array. The scatter plot (**Figure 20**) shows the predicted maximum SEL across the water column from the source array for all azimuths as a function of range from the centre of the acoustic source. The mitigation threshold levels (186 dB re 1μPa^2·s for PTS and 171dB re 1μPa^2·s for TTS) and Code of Conduct mitigation zones (200 m injury mitigation zone, and 1.0 km and 1.5 km behaviour mitigation zone for species of conern with and without calf present respectively) are also shown.

The results for modelling at Gladstone-1 are summarised in **Table 19**. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are provided in **Table 20**.

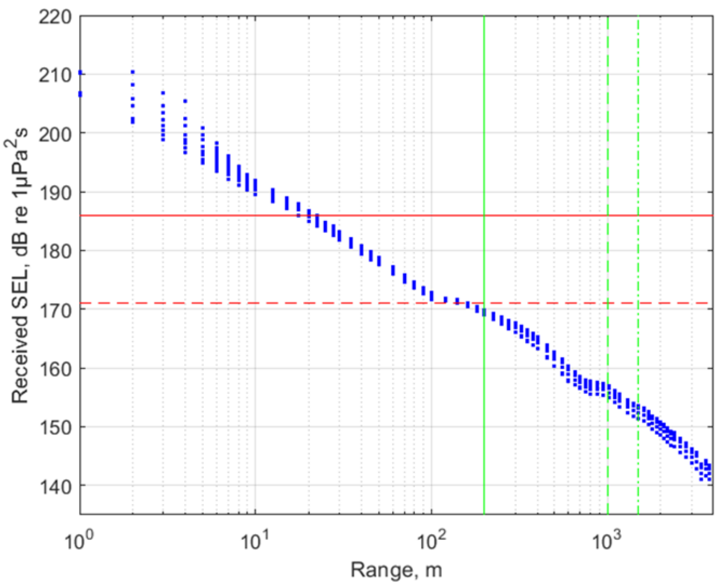
The results provided in **Table 19** demonstrate that the maximum received SELs from the checkshot survey within the Gladstone-1 Operational Area are predicted to be below 186 dB re 1μPa²·s at 200 m and below 171 dB re 1μPa²·s at 1 km and 1.5 km. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are 22.1 m for the 186 dB re 1μPa².s threshold, and 164.0 m for the 171 dB re 1μPa².s threshold (**Table 20**).

Figure 19 Predicted Maximum Received SELs across the Water Column at Gladstone-1 as a Function of Azimuth and Range from the Centre of the Array



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

Figure 20 Scatter Plot of Maximum Received SELs from the Acoustic Source at Gladstone-1



Note: Horizontal red lines show mitigation thresholds of 186 dB re 1μPa²·S (solid) and 171 dB re 1μPa²·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Table 19 Predicted Maximum SELs at the Standard Code of Conduct Mitigation Zones for the Gladstone-1 Operational Area

Location	Water Depth (m)	SELs at different ranges (dB re 1µPa2·S)		
		200 m	1.0 km	1.5 km
Gladstone-1	135	169.9	157.0	153.5

Table 20 Ranges from the Centre of the Array where the Predicted Maximum SEL Equals the SEL Threshold Levels within the Gladstone-1 Operational Area

Source Location	Ranges complying with the SEL thresholds (m)	
	186 dB re 1µPa2·S	171 dB re 1µPa2·S
Gladstone-1	22.1	164.0

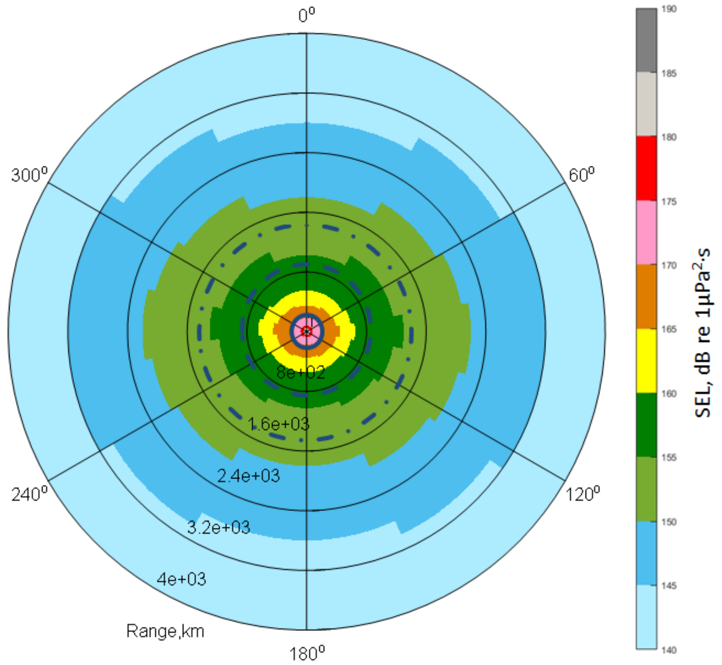
6.2.2.1.2 Toutouwai-1 Modelling Results

The results of the short-range modelling at Toutouwai-1 are depicted in **Figure 21** and **Figure 22**. **Figure 21** depicts the maximum received SELs across the water column as a function of azimuth and range from the centre of the array. The predicted maximum SELs across the water column from the source array for all azimuths as a function of range form the centre of the acoustic source, as well as the mitigation threshold levels and Code of Conduct mitigation zones are shown in **Figure 22**.

The results for modelling at Toutouwai-1 are summarised in **Table 21**. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are provided in **Table 22**.

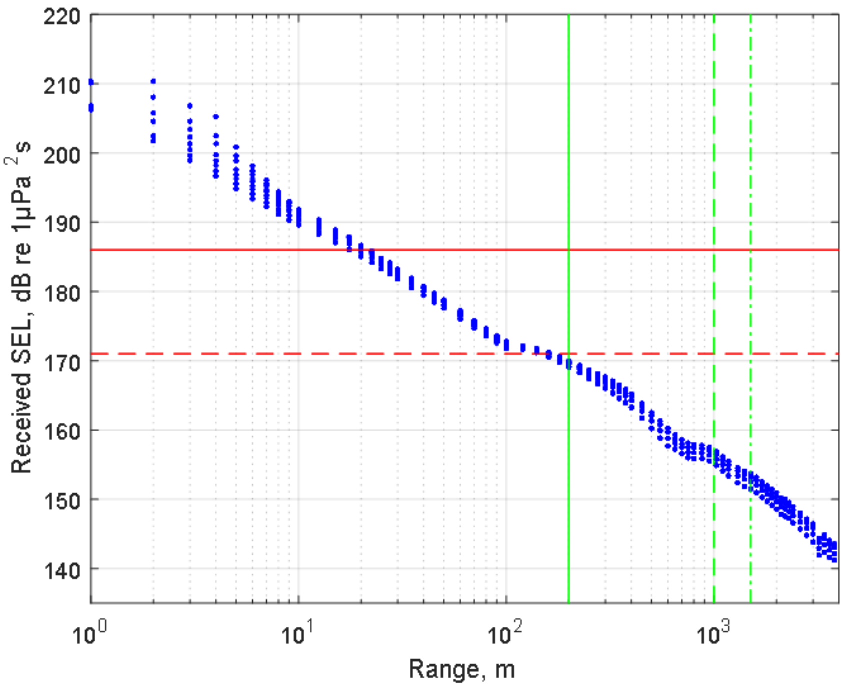
The results provided in **Table 21** demonstrate that the maximum received SELs from the checkshot survey within the Toutouwai-1 Operational Area are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1 km and 1.5 km. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are 22.2 m for the 186 dB re 1µPa^2·s threshold, and 166.5 m for the 171 dB re 1µPa^2·s threshold (**Table 22**).

Figure 21 Predicted Maximum Received SELs across the Water Column at Toutouwai-1 as a Function of Azimuth and Range from the Centre of the Array



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

Figure 22 Scatter Plot of Maximum Received SELs from the Acoustic Source at Toutouwai-1



Note: Horizontal red lines show mitigation thresholds of 186 dB re 1µPa²·S (solid) and 171 dB re 1µPa²·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Table 21 Predicted Maximum SELs at the Standard Code of Conduct Mitigation Zones for the Toutouwai-1 Operational Area

Location	Water Depth (m)	SELs at different ranges (dB re 1µPa2·S)		
		200 m	1.0 km	1.5 km
Toutouwai-1	131	170.1	157.1	153.7

Table 22 Ranges from the Centre of the Array where the Predicted Maximum SEL Equals the SEL Threshold Levels within the Toutouwai-1 Operational Area

Source Location	Ranges complying with the SEL thresholds (m)	
	186 dB re 1µPa2·S	171 dB re 1µPa2·S
Toutouwai-1	22.2	166.5

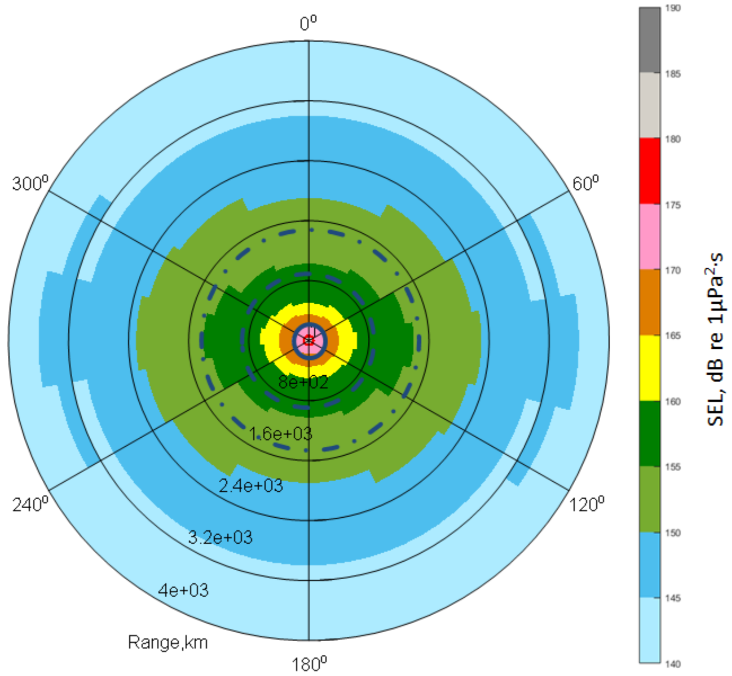
6.2.2.1.3 Māui-8 Modelling Results

Figure 23 and **Figure 24** depict the results of the short-range modelling at Māui-8. Figure 23 depicts the maximum received SELs across the water column as a function of azimuth and range from the centre of the array. **Figure 24** shows the predicted maximum SEL across the water column from the source array for all azimuths as a function of range from the centre of the acoustic source. The mitigation threshold levels (186 dB and 171dB re 1µPa^2·s) and Code of Conduct mitigation zones (200 m, 1.0 km and 1.5 km) are also shown in **Figure 24**.

The results for modelling at Māui-8 are summarised in **Table 23**. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are provided in **Table 24**.

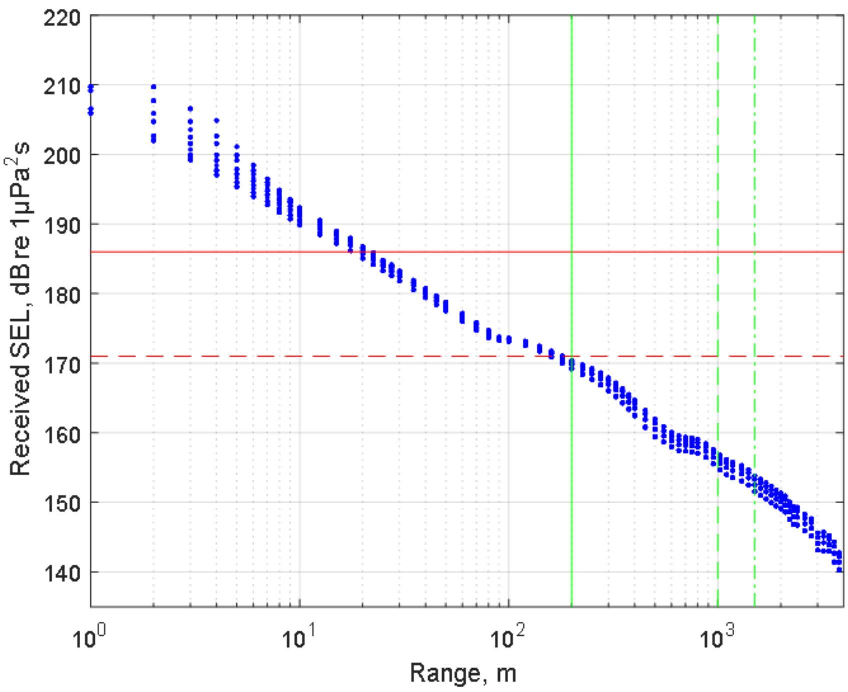
The results provided in **Table 23** demonstrate that the maximum received SELs from the checkshot survey within the Māui-8 Operational Area are predicted to be below 186 dB re 1µPa^2·s at 200 m and below 171 dB re 1µPa^2·s at 1 km and 1.5 km. The ranges from the centre of the array where the predicted maximum SELs will reach the Code of Conduct SEL thresholds are 22.2 m for the 186 dB re 1µPa^2·s threshold, and 181.4 m for the 171 dB re 1µPa^2·s threshold (**Table 24**).

Figure 23 Predicted Maximum Received SELs across the Water Column at Māui-8 as a Function of Azimuth and Range from the Centre of the Array



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

Figure 24 Scatter Plot of Maximum Received SELs from the Acoustic Source at Māui-8



Note: Horizontal red lines show mitigation thresholds of 186 dB re 1μPa²·S (solid) and 171 dB re 1μPa²·S (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

Table 23 Predicted Maximum SELs at the Standard Code of Conduct Mitigation Zones for the Māui-8 Operational Area

Location	Water Depth (m)	SELs at different ranges (dB re 1µPa2·S)		
		200 m	1.0 km	1.5 km
Māui-8	110	170.4	157.2	154.0

Table 24 Ranges from the Centre of the Array where the Predicted Maximum SEL Equals the SEL Threshold Levels within the Māui-8 Operational Area

Source Location	Ranges complying with the SEL thresholds (m)	
	186 dB re 1µPa2·S	171 dB re 1µPa2·S
Māui-8	22.2	181.4

6.2.2.2 Potential Physiological Effects

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

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

6.2.2.2.1 Zooplankton

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

McCauley *et al*. (2017) provided evidence to suggest that seismic surveys may cause significant mortality to zooplankton populations. McCauley *et al*. (2017) assessed the health of the plankton community in relation to exposure to a single 150 in^3 acoustic source using sonar surveys and zooplankton net tows to determine zooplankton abundance and counts of dead zooplankton before and after seismic exposure. McCauley *et al*. (2017) found reductions on zooplankton abundance within 509 – 658 m from the source, with the range of no impact on zooplankton abundance occurring at 973 – 1,119 m. Post-exposure there was two to three times more dead zooplankton and 100% mortality in krill larvae at all distances. Sonar backscatter showed a 'hole' in the plankton community up to 30 m deep that followed the prevailing track of the seismic source and was detectable from 15 minutes after exposure (McCauley *et al*., 2017).

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

An additional independent review (IAGC, 2017) was also done in order to address the results published by McCauley *et al*. (2017) as the results were so inconsistent with previously documented effects. Overall, the reviewers "*expressed the opinion that although the results of the study should be considered further, the data were not sufficient to support the conclusions offered by McCauley et al. (2017)*". The reasons for this were:

1. The sample size was inadequate;
2. Water column movement data were insufficient to support the contention of a "hole" in the plankton field;
3. Towed net and acoustic survey data disagreed regarding zooplankton class size;
4. The acoustic "hole", which was taken to indicate dead zooplankton, may simply have resulted from zooplankton which had swum to the bottom which was just 10 m away;
5. Bottom sampling should have been conducted to address the questions of whether the large zooplankton were present, whether they had been killed and sunk to the bottom, or whether they actively swam to the bottom;
6. The wrong sized nets were used and were not towed correctly; and
7. There was statistical error in the net tow data.

The results of the review were shared with the authors of McCauley *et al*. (2017) and the authors concurred with many of the shortcomings identified by the reviewers.

It is important to put the results from Richardson *et al*. (2017) and McCauley *et al*. (2017) into context with regard to the Taranaki Checkshot Surveys. Richardson *et al*. (2017) modelled an acoustic source with a volume of 3,200 in^3, with the model run over an area of 2,900 km^2 for 35 days. The acoustic source used in each Taranaki Checkshot Survey will have a total volume of 450 in^3 so is significantly smaller than that used in Richardson *et al.* (2017). Furthermore, the findings of Richardson *et al*. (2017) and McCauley *et al.* (2017) are based on a 3D seismic survey operating over a wide area for an extended period of time. The Taranaki Checkshot Surveys will occur from a single fixed location within each Operational Area, with each survey taking up to 12 hours to complete, but more accurately it is considered to be within 3.8 to 9.3 hours. Unlike a 3D seismic survey whereby the acoustic source is activated approximately every ten seconds, the acoustic source during the Taranaki Checkshot Surveys will be activated approximately every 1.5 – 2 minutes.

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

While the potential for mortality of zooplankton during the Taranaki Checkshot Surveys cannot be completely ruled out, based on the small volume acoustic source that will be used, any effects will likely be restricted to within the immediate vicinity of the acoustic source (i.e. within a few meters). Due to the stationary nature of the MODU and acoustic source, there will not be any wide-ranging or population-level effects on zooplankton. Movements of water masses from outside the disturbance zone will rapidly replenish any zooplankton populations that may have been depleted by acoustic disturbances. The residual risk of physiological effects on zooplankton populations due to acoustic disturbance from the Taranaki Checkshot Surveys is considered to be **minor**.

6.2.2.2.2 Benthic Invertebrates

Many marine invertebrates have mechanoreceptors (sensory hairs or organs), which bear some resemblance to vertebrate ears, and are sensitive to sound. For example, in crustaceans, the main vibration receptors are in the statocysts and the walking legs (Aicher *et al*., 1983). McCauley (1994) reported that for many benthic species, these receptors will perceive seismic acoustic outputs, but this will only occur within a few metres from the sound source.

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

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

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

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

- Statocyst hair cells sustained long-term damage following seismic exposure; however, these lobsters did not show impaired righting reflexes suggesting that affected individuals had adapted to cope with this damage; and
- Haemolymph biochemistry showed no response to seismic exposure, indicating that lobsters were physiologically resilient to acoustic disturbance; however, haemolymph counts were slightly lower in exposed lobsters than in control lobsters and the relevance of this lowered haemolymph count is unknown.

Day *et al* (2016) also exposed scallops (*Pecten fumatus*) and found exposed animals had significantly lower haemocyte levels (a proxy for circulation, immunity and stress) in response to seismic exposure when compared to control scallops). Day *et al*. (2016) noted that the ecological implications of these changes warrant further investigation, although it seems that exposed scallops could suffer from a depressed immune response.

Due to the short-term nature of the proposed Taranaki Checkshot Survey, the highly localised area of potential effects and low abundance of invertebrates expected in close proximity of the MODU, the overall residual risk of physiological effects on benthic invertebrates is assessed as **negligible**.

6.2.2.2.3 Cephalopods

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

Squid form pelagic schools over the continental shelf in water depths up to 500 m but are most prevalent in water depths less than 300 m (MPI, 2015). Given their distribution there is the potential for schools of squid to be exposed to acoustic disturbance during the Taranaki Checkshot Surveys. However, their pelagic life style means that squid can readily move away from the highest sound levels close to the acoustic source and avoid physiological damage.

Octopus species that could be present in the offshore Taranaki area are typically solitary and demersal. It is possible that individual octopuses could be subjected to acoustic exposure during the checkshot surveys in the event that the individual was in very close proximity to the MODU. However, given the lack of cryptic habitat in the relatively flat muddy seabed around the well locations only occasional individuals may be affected.

No specific mitigation measures will be in place to reduce the potential effects of seismic surveys on cephalopods; and based on the information above the residual risk of physiological trauma to cephalopods through acoustic disturbance during the Taranaki Checkshot Surveys is considered to be **negligible**.

6.2.2.2.4 Fish

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

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

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

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

Popper *et al*. (2014) developed guidelines to predict at what threshold levels seismic surveys may cause physiological damage to fish. Using fish with a swim bladder that is involved with hearing as a worst-case scenario, mortality and potential mortal injury may occur at levels greater than 207 dB re 1 µPa. Based on the STLM results, such noise levels would only occur within a few meters of the acoustic source. High densities of fish are not expected to be present in close proximity to the acoustic source, and any species present are likely to be highly mobile with no fixed territories so able to move away from the disturbance. The potential for residual physiological effects on fish populations from acoustic disturbance during the Taranaki Checkshot Surveys has been assessed as **negligible**.

6.2.2.2.5 Marine Reptiles

Given the rare occurrences of marine reptiles in Taranaki waters (DOC, 2019f) (**Section 5.2.8**) it is unlikely that any marine reptiles will be present at the well locations during the checkshot surveys. Physiological effects have not been observed in marine reptiles in response to seismic surveys, although patterns of avoidance and behavioural responses have been observed (**Section 6.2.2.3.4**).

Due to the unlikely occurrence of marine reptiles in the Operational Areas it is considered that the residual risk of behavioural effects from acoustic disturbance during the Taranaki Checkshot Surveys to marine reptiles will be **negligible**.

6.2.2.2.6 Seabirds

As high-intensity acoustic disturbances have the potential to cause physiological injury to marine mammals, it is reasonable to assume that diving seabirds could also suffer physiological harm. Seabirds on the sea surface are unlikely to suffer physiological effects as the "Lloyd mirror effect" means that noise levels at the surface are lower than those deeper in the water column (Carey, 2009); only seabirds that dive in close proximity to the acoustic source will be at risk of suffering physiological damage. To date there is limited evidence of physiological effects from seismic surveys on seabirds, with all documented effects limited to behavioural effects (see **Section 6.2.2.3.5**).

Due to their largely aquatic lifestyle and lack of flight ability, little penguins will be more susceptible to physiological effects from the checkshot surveys than other seabirds expected to be in the Operational Areas. As described in **Section 5.2.9.1**, little penguins utilise South Taranaki Bight offshore areas for foraging and may be present, particularly within the Māui-8 Operational Area. While penguins and diving seabirds may occur within the Operational Areas, foraging in close proximity to the MODU is unlikely as the small fish that constitute seabird prey will likely be displaced from the immediate vicinity of the active acoustic source. Changes in prey distribution will be detected by seabirds, and foraging would cease, reducing their exposure to potential physiological effects.

Based on the discussion above, the residual risk of physiological effects to seabirds from acoustic disturbance during the Taranaki Checkshot Surveys is considered to be **negligible**.

6.2.2.2.7 Marine Mammals

Marine mammals are highly vocal and dependent on sound for almost all aspects of their lives (Weilgart, 2007). In the event that a marine mammal is exposed to high-intensity underwater noise at close range, lethal and sub-lethal physiological effects may occur (Gordon *et al*., 2003). The sound intensities required to elicit such effects are largely unknown for most species, and current knowledge on traumatic thresholds is based on few experimental species (e.g. Southall et al., 2007; NOAA, 2018).

The main type of auditory damage documented in marine mammals is known as a 'threshold shift' whereby exposed individuals exhibit an elevation in the lower limit of their auditory sensitivity; they experience hearing loss. Threshold shifts can be permanent or temporary, with temporary shifts more common in marine mammals as noise levels that elicit TTS will be experienced over much larger areas than those that elicit PTS and therefore more animals are potentially exposed. However, exposure to sounds that can cause a temporary threshold shift can usually cause a permanent threshold shift (i.e. permanent hearing loss) if the animal is repeatedly exposed for a sufficient period of time (Gordon *et al*., 2003) Very high SELS are believed to be required to cause immediate serious permanent physiological damage in marine mammals (Richardson *et al*., 1995). A permanent threshold shift is thought to occur at 186 - 198 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. These thresholds follow Southall *et al*. (2007). The 'injury criteria' (i.e. threshold above which a permanent threshold shift would be expected) is exceeded if marine mammals are subject to SELs greater than 186 dB re 1μPa^2.s. A temporary threshold shift is predicted to occur at 183 dB re 1 μPa^2-s for all cetaceans and 171 dB re 1 μPa^2-s for pinnipeds. The Code of Conduct requires mitigation measures that have been specifically designed to minimise the potential for marine mammals to be subject to SELs that could cause temporary or permanent threshold shifts. Compliance with the Code of Conduct mitigation measures (see **Section 3.5**) is the fundamental way in which auditory damage in marine mammals will be avoided during the Taranaki Checkshot Surveys. The protocol that the MMOs and PAM Operators will follow during the Taranaki Checkshot Surveys is detailed in the MMMP (**Appendix D**).

STLM results for the Taranaki Checkshot Surveys indicated that compliance with the 186 dB re 1µPa^2.s threshold occurs at a maximum distance of 22.1 m (Gladstone-1), 22.2 m (Toutouwai-1), and 22.2 m (Māui-8) (**Table 24**). As sound levels that could cause physiological damage would only occur in very close proximity to the acoustic source, compliance with the standard Code of Conduct mitigation zones will sufficiently protect marine mammals from physiological effects. As per the Code of Conduct requirements, ground-truthing during the survey will be carried out to verify the results of the STLM.

The risk of physiological injury increases for any marine mammal that approaches the acoustic source closer than approximately 22 m (based on STLM results). New Zealand fur seals have been known to aggregate around the platforms and FPSOs '*Raroa*' and '*Umuroa*' in the Taranaki Basin. As the MODU from which the acoustic equipment will be deployed will have been on location for approximately 25 – 50 days, New Zealand fur seals may have aggregated around the MODU and so may be close enough to experience physiological injury. The design of the MODU associated with the Taranaki and Māui EAD Programmes reduces the likelihood of New Zealand fur seals from settling on the MODU structure (i.e. a semi-submersible MODU with no exposed structure for resting sites); however, as per the Code of Conduct, start up will be delayed if a New Zealand fur seal is observed during pre-start observations within 200 m of the source.

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

If exceedances of the physiological threshold for individual marine mammals do occur during the Taranaki Checkshot Surveys, a temporary threshold shift may occur. However, threshold shifts are unlikely due to the typical avoidance behaviour exhibited by marine mammals, and compliance with the Code of Conduct (i.e. pre-start observations, delayed starts and shutdowns). This serves to minimise the risk to marine mammals to as low as reasonably practicable. Marine mammals would have to be in extremely close proximity to the acoustic source to experience physiological trauma. On this basis the residual risk of physiological effects on marine mammals is considered to be **moderate**.

6.2.2.3 Potential Behavioural Effects

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

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

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

6.2.2.3.1 Benthic Invertebrates

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

Research has shown that avoidance behaviours to sound have longer-lasting effects on populations than startle responses. Hawkins *et al*. (2015) reports that, at lower sound levels, behavioural responses are more likely to occur than physical and/or physiological responses. Behavioural responses are, however, the most difficult to monitor *in situ* and consequently, many studies investigating the effects of seismic operations on the behaviour of benthic invertebrates are conducted under laboratory conditions or by deploying caged individuals in the field (Carroll *et al*. 2017).

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

Christian *et al*. (2003) examined snow crab behaviour before, during and after exposure to seismic outputs and observed that in the laboratory crabs reacted slightly when sharp sounds were made near them. However, in the field, caged crab showed no readily visible reactions to the 200 in^3 acoustic source operating 50 m above them. Tagged crabs did not undergo any large-scale movements out of the area.

There is a lack of information with regard to the behavioural effects of seismic surveys on shellfish. As reported by Carroll *et al*. (2017), two studies have shown evidence of a startle response in bivalves at realistic sound exposure levels (Day *et al*. 2016; Roberts *et al*. 2015), although only Day *et al*. (2016) used seismic outputs as the sound source. Day *et al*. (2016) reported that scallops exposed to seismic display a distinctive flinching response, an increase in burial rate and are slower at righting themselves than control scallops. No energetically costly responses, such as swimming, have been observed in scallops due to exposure to an acoustic source.

The benthic invertebrates found within the Operational Areas are dominated by small polychaete worms (**Section 5.2.3**); although others can be expected such as amphipods, ostracods and bivalves. The Taranaki Checkshot Surveys will be undertaken over a very short period of time (approximately 3.8 to 9.3 hours) limiting the potential for long-term risks to benthic invertebrates. Based on the STLM modelling results, high noise levels will only occur in very close proximity to the acoustic source. The residual risk of behavioural impacts of benthic invertebrates from acoustic disturbance during the Taranaki Checkshot Surveys has therefore been assessed as **negligible**.

6.2.2.3.2 Cephalopods

Behavioural changes in response to acoustic disturbance have been documented for cephalopods. Caged cephalopods exposed to acoustic sources demonstrated a startle response above 151 – 161 dB re 1 µPa and tended to avoid the acoustic disturbance by exhibiting surface behaviours (McCauley *et al*., 2000). McCauley *et al*. (2000) suggested that thresholds affecting squid behaviour occur at 161 – 166 dB re 1 µPa rms. McCauley *et al*. (2000) also found that the use of soft-starts effectively decreased the startle response; soft-starts will be undertaken in accordance with the Code of Conduct (**Section 3.5.7**).

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

A subsequent study (Fewtrell & McCauley, 2012) further demonstrated that a source level of 147 dB re 1 µPa was necessary to induce an avoidance reaction in squid. Fewtrell & McCauley (2012) observed other reactions, including alarm responses (such as inking and jetting away from the source), increased swimming speed and aggressive behaviour. The authors found that there was an increase in the alarm response from the squid as the acoustic release noise levels increased beyond 147 – 151 dB re 1 µPa SEL. As in Fewtrell (2003) the reaction of the animals decreased with repeated exposure to the acoustic source suggesting either habituation or impaired hearing (Fewtrell & McCauley, 2012).

Given their pelagic lifestyle, there is the potential for squid to come near the acoustic source during the Taranaki Checkshot Surveys. However, noise levels required to elicit a behavioural response will only be reached in relatively close proximity (i.e. approximately 1.5 km) to the acoustic source. Consequently, the residual risk of behavioural impacts to cephalopods from acoustic disturbance during the Taranaki Checkshot Surveys has been assessed as **minor**.

6.2.2.3.3 Fish and Commercial Fisheries

Behavioural responses of fish to acoustic disturbances vary depending on species traits, with the presence or absence of a swim bladder a major factor; species with swim bladders or other gas-filled chambers are generally more sensitive to sound and more likely to suffer adverse effects.

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

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

Short-term responses are relatively common, and include startle responses (Pearson *et al*., 1992; Wardle *et al*., 2001; Hassel *et al*., 2004; Boeger *et al*., 2006), modification in schooling patterns and swimming speeds (Pearson *et al*., 1992; McCauley *et al*., 2000; Fewtrell & McCauley, 2012), freezing (Sverdrup *et al*., 1994), and changes in vertical distribution within the water column (Pearson *et al.,* 1992; Fewtrell & McCauley, 2012).

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

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

Commercial fishing around the Gladstone-1 Operational Area is relatively high and fishing effort at the Toutouwai-1 Operational Area is low, while fishing effort occurs around the Māui-8 Operational Area by the blue and jack mackerel fishery. The presence of the MODU throughout the duration of the wider Taranaki EAD Programme will restrict commercial fishing operations in close proximity to the Operational Areas. Based on the lack of evidence of long-term effects on fish stocks, extremely short-term duration of behavioural effects, and restricted spatial extent of any effects, and very small area of space from which commercial fishers are excluded, the residual risk of behavioural effects on fish and flow-on effects on commercial fishery catch rates has been assessed as **minor**.

6.2.2.3.4 Marine Reptiles

No information is available on the effects of seismic surveys on sea snakes, but patterns of avoidance and behavioural changes have been observed in sea turtles. Captive sea turtles (i.e. loggerhead and green turtles) exposed to an approaching acoustic source displayed a behavioural response of an increase in swimming speed and an avoidance response of erratic swimming (McCauley *et al*., 2000). Avoidance behaviours in loggerhead turtles were also documented by De Ruiter and Doukara (2012); turtle dive probability decreased with increasing distance to the acoustic source, with the dive response interpreted as an avoidance behavioural response (De Ruiter & Doukara, 2012).

Due to the highly unlikely occurrence of marine reptiles in the Operational Areas, the short-term nature of the checkshot surveys, and the small volume of the acoustic source, it is considered that the residual risk of behavioural effects to marine reptiles from acoustic disturbance during the Taranaki Checkshot Surveys will be **negligible**.

6.2.2.3.5 Seabirds

There is little information about the behavioural effects from seismic on seabirds; however, the possibility of disruption to feeding activities has been identified. Goudie and Ankney (1986) suggest that seabird feeding behaviours could be interrupted by acoustic disturbance from a seismic vessel passing through feeding grounds, and MacDuff-Duncan and Davies (1995) postulated that birds in the area could become alarmed as seismic operations pass close-by, causing them to temporarily stop diving. Although these studies relate to seismic surveys from a vessel moving into feeding grounds, similar behavioural effects on feeding birds could be expected for the Taranaki Checkshot Surveys should seabirds be present and/or feeding around the MODU. In addition to the potential direct displacement of seabirds, the displacement of bait fish may lead to a reduction in diving activities and foraging potential for seabirds in the immediate vicinity of seismic operations. Further assessment on these potential effects on prey species are provided for within **Section 6.2.2.5**.

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

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

Although the Lacroix *et al.* (2003) and Pichegru *et al*. (2017) studies were not carried out on species expected within the Operational Areas, their results suggest that, at most, seabirds will be temporarily displaced from areas of active seismic operations. These displacement effects are anticipated to be short-lived, with animals able to return to traditional feeding grounds after seismic operations are completed. The very short-term duration of the Taranaki Checkshot Surveys will minimise disturbance to seabird behaviour. Consequently, the residual risk of behavioural effects on seabirds from acoustic disturbance during the Taranaki Checkshot Surveys has been assessed as **negligible**.

6.2.2.3.6 Marine Mammals

Many authors have documented an avoidance of seismic operations in marine mammals (e.g. Goold, 1996; Stone & Tasker, 2006; Thompson *et al*., 2013). While behavioural responses may not have direct lethal effects, there is potential for sub-lethal effects such as increases in energy expenditure and demand, decreased foraging efficiency, disruption of group dynamics (e.g. group cohesion), and lowered reproductive rates leading to population-wide effects (Weilgart, 2007; 2013). Behavioural effects may also be harmless (Weilgart, 2007).

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

Increased surface behaviours such as breaching or increases in time spent at the surface has been interpreted as a way of reducing exposure to high sound levels on account of the 'Lloyd mirror effect' (Carey, 2009). The Lloyd mirror effect significantly reduces the sound intensity within the upper-most part of the water column. For example, observations of migrating humpback whales off Australia in response to an operating 3D seismic survey suggested humpback whales extended surface behaviours in order to reduce received sound levels (McCauley *et al*., 2000). Whales also consistently undertook avoidance manoeuvres in the form of altered course and speed (McCauley *et al*., 2000). Other stress-related behaviours that have been documented in the vicinity of operating seismic surveys include changes in respiration rate (Richardson *et al*., 1995), swimming speed (Stone & Tasker, 2006), and alterations to diving behaviour (Richardson *et al*., 1995).

McCauley *et al*. (2000) hypothesised that migrating whales are less sensitive to acoustic disturbance from seismic sources and are at low risk to seismic activities, while whales engaging in resting behaviours at key habitats are particularly sensitive. Humpback whales carry out migrations to breeding grounds using migration routes that include the Taranaki Bight, from late May to early August for northern migrations, and from September to December during southern migrations. In open seas, such as within the Taranaki Basin, it is unlikely that a temporary displacement would have significant energetic consequences for migrating whales; consequences of displacement more severe in confined areas. It is therefore unlikely that the Taranaki Checkshot Surveys will have any significant effect on humpback whale migrations.

Marine mammal distribution is typically linked to that of their prey (Fielder *et al*., 1998), and any avoidance response could lead to abandonment of valuable feeding grounds (e.g. large aggregations of krill) or reduced foraging effort. As described within **Section 5.2.6.2**, the South Taranaki Bight has been identified as a summer feeding area for pygmy blue whales, with any effects on this species particularly relevant to the Māui-8 Operational Area, and to a lesser extent the Toutouwai-1 Operational Area. McDonald *et al*. (1995) suggested blue whales may be more sensitive to noise emissions than other baleen whales, with tracked blue whales observed avoiding an active seismic vessel at distances of up to 10 km.

The summer distribution of pygmy blue whales in the South Taranaki Bight is highly variable and is dependent on oceanic conditions resulting in upwellings that drive the distribution of their prey. In El Niño conditions whales tend to be located west of the South Taranaki Bight, but inside the South Taranaki Bight during more typical weather patterns (Torres & Klinck 2016). Although acoustic disturbance from seismic surveys has been recorded to elicit a behavioural response in blue whales, any summer feeding aggregations will likely be to the south-west of the Maūi-8 Operational Area and well outside of the area where behavioural effects are predicted to occur (see **Section 6.2.2.1** for STLM results).

An onset threshold for TTS of 171 dB re 1µPa^2.s SEL has been adopted by the Code of Conduct for minimising behavioural disturbances to marine mammals. Based on the results of the STLM, this threshold will be met at distances of 164 m (Gladstone-1), 166.5m (Toutouwai-1), and 181.4 m (Māui-8) from the acoustic source (**Table 23**). Based on these results, the standard Code of Conduct mitigation zones of 1 km and 1.5 km will be sufficient to protect marine mammals (without and with calf respectively) from TTS during the Taranaki Checkshot Surveys.

There is anecdotal evidence of attraction of marine mammals to seismic operations. McCauley *et al.* (2000) observed what are believed to be male humpback whales approaching an operating acoustic source and hypothesised that this was due to the similarity to sounds produced by humpback whale breaching. New Zealand fur seals are also known to approach operating seismic vessels (Lalas & McConnell, 2016) and will likely be present within Taranaki waters during the checkshot surveys, particularly within the Māui-8 Operational Area on account of its proximity to existing structures where they are known to aggregate.

With regard to the potential behavioural impacts on marine mammals during the Taranaki Checkshot Surveys, the following considerations should be noted:

- The Taranaki Checkshot Surveys will run for a short period of time and will use a relatively small volume acoustic source, minimising sound emissions into the marine environment;
- Any avoidance or displacement will be temporary and will cease as soon as each survey is complete;
- New Zealand fur seals will likely be present within the Operational Areas;

- Avoidance behaviours could force marine mammals to leave feeding grounds (e.g. large aggregations of krill), causing an increase in energy expenditure in order to locate prey aggregations elsewhere. This is particularly relevant within the Māui-8 Operational Area during summer months, although displacement is unlikely to occur given the low sound emissions from each survey; and
- Cook Strait is used as a migration corridor by blue and humpback whales, primarily in winter months. Due to the distance of the Operational Areas from the confines of Cook Strait, small acoustic source, and short duration of each checkshot survey, disruption to migration behaviours is not considered to be a key concern.

Compliance with the Code of Conduct will be the primary mitigation measure employed during each checkshot survey to manage behavioural effects on marine mammals. In accordance with the Code of Conduct, the following will be employed:

- Qualified MMOs and PAM Operators will be present on the support vessel and will maintain visual and acoustic watch (including pre-start observations) for marine mammals and will implement the mandatory management actions when required (e.g. delayed starts and shut-downs);
- The specifications of the PAM system proposed for the checkshot surveys will be assessed by DOC to ensure that the system meets the standards described in the Code of Conduct (i.e. suitable to detect vocalisations from all Species of Concern that could potentially be in the Operational Area). Full technical specifications of the PAM system are provided in **Appendix B**; and
- STLM has been undertaken to assess the validity of the Code of Conduct standard mitigation measures. STLM results confirm that the standard mitigation measures will be sufficient to protect marine mammals from behavioural effects.

In addition to the Code of Conduct measures, MMOs onboard the support vessel will immediately notify DOC of any Hector's/Māui's dolphin sightings.

The full protocol that the MMOs and PAM Operators will be following during the Taranaki Checkshot Surveys is detailed in the MMMP. The MMMP is provided in **Appendix D**.

Based on the discussions above and mitigation measures that will be implemented, any incidents of TTS from the Taranaki Checkshot Surveys are expected to be confined to within the immediate vicinity of the acoustic source (i.e. <200 m based on STLM results) and given compliance with the Code of Conduct TTS in marine mammals is unlikely. In the event that TTS does occur, affected animals will recover once the vessel passes or they move away. No long-term behavioural effects or long-term displacement are predicted. As a result, the residual risk of behavioural effects on marine mammals from the Taranaki Checkshot Surveys is considered to be **moderate** (i.e. limited to behavioural changes and masking).

6.2.2.4 Potential Perceptual Effects

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

The effects of masking on an animal's fitness and survival include:

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

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

6.2.2.4.1 Fish

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

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

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

Although little is known on the vocalisations of fish throughout the Taranaki Basin, it is reasonable to assume that the Taranaki Checkshot Surveys may lead to masking for some fish species. However, based on the highly mobile nature and likely low abundances of the fish potentially present in the Operational Areas, and the short duration of each checkshot survey (i.e. approximately 3.8 to 9.3 hours), no biologically significant effects are expected and the residual risk of perceptual effects on fish is considered to be **minor**.

6.2.2.4.2 Marine Mammals

The ability to perceive biologically important sounds is crucial to marine mammals; marine mammals use sounds to gain an overall awareness of the surrounding environment, and to inform a variety of behaviours including foraging, navigation, communication, reproduction, parental care, predator avoidance (Thomas *et al*., 1992; Johnson *et al*., 2009). Sounds in the same frequency as biological signals can interfere with biologically important sounds and potentially lead to significant individual effects (Gausland, 2000). Masking is a common effect of acoustic disturbance on marine mammals (Erbe *et al*., 2016). The level of masking that will occur depends on a number of factors other than the noise doing the masking, such as the location of the sender and receiver, source level and spectral characteristics of the signal, and the receiving animal's auditory capabilities (Erbe *et al*., 2016).

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

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

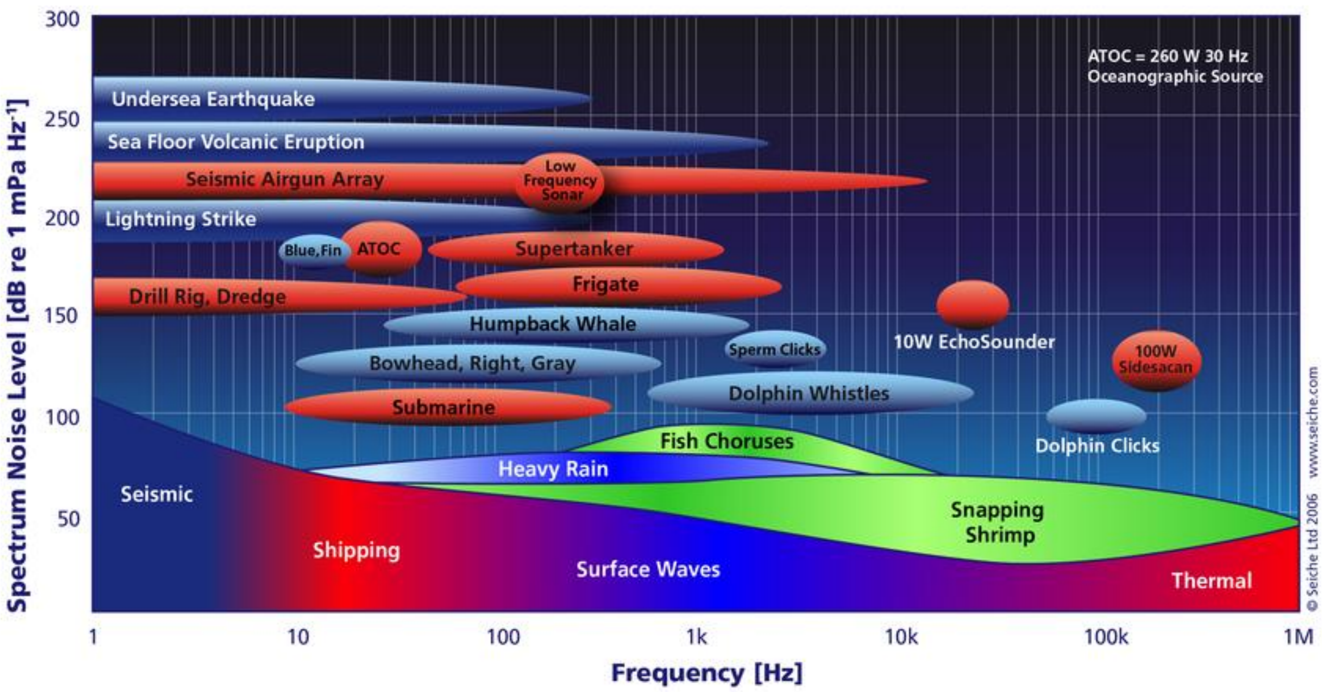
Sound frequencies emitted by seismic acoustic sources are broadband, but with most of the energy concentrated between 0.1 kHz and 0.25 kHz. The greatest potential for interferences with cetacean vocalisations is at the highest end of the seismic spectrum and the lowest end of the cetacean vocalisation spectrum (**Table 25**) i.e. the lowest frequency cetaceans are particularly affected since they have the most overlap with the frequencies of the seismic survey acoustic sources (**Figure 25**). Auditory masking of mid and high frequency cetacean vocalisations is less likely as these species generally operate at higher frequencies than those generated by a seismic survey.

Table 25 Examples of 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
Blue whale	0.0124 – 0.4	N/A
Fin whale	0.01 – 28	N/A
Humpback whale	0.025 – 10	N/A
Sperm whale	0.1 - 30	0.1 – 30
Pygmy sperm whale	No data available	60 – 200
Beaked whales*	3 – 16	2 – 26
Common dolphin	0.5 – 18	0.2 – 150
Pilot whale	1 – 18	1 – 18
Killer whale	0.1 – 35	12 – 25
Bottlenose dolphin	0.2 – 24	110 – 130
* = using the bottlenose whale as an example		

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

Figure 25 Ambient and Localised Noise Sources in the Ocean



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

Erbe *et al*. (2016) documented a number of studies demonstrating adaptive responses/anti-masking strategies in cetaceans reacting to underwater anthropogenic noise, including changes in vocalisation strength, frequency, and timing. For example, blue whales increase their calls (emitted during social encounters and feeding) when a seismic survey is operational in the area (Di lorio & Clark, 2009). Adaptations have also been documented in humpback whales (McCauley *et al*., 1998; 2003a), beluga whales (Lesage *et al*., 1999), right whales (Parks *et al*., 2007, 2011), killer whales (Holt *et al.*, 2008), and bottlenose dolphins (van Ginkel *et al*., 2017). It is thought that an increase in calling leads to an increase in the probability that signals will be successfully received by conspecifics due to a reduction in the effects of auditory masking.

Cetaceans may also cease vocalising in response to anthropogenic noise, as has been demonstrated in humpback whales at breeding grounds off Angola in response to a MSS whereby singing activity declined with the presence of the MSS and increasing received levels of the seismic pulses (Cerchio *et al*., 2014). This cessation in singing at a breeding ground was implied to have the potential to affect mating behaviour and success (Cerchio *et al*., 2014). Cessation in clicking was also observed in sperm whales by Bowles *et al.* (1994) in response to weak seismic survey pulses (received level of 115 dB re 1 µPa). Contradictory to the findings of Bowles *et al.* (1994), Madsen *et al*. (2002a) did not document any changes in male sperm whale clicks in response to a seismic survey off Norway. Sperm whales did not cease clicking and did not alter normal acoustic behaviour during feeding (Madsen *et al*., 2002a).

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

Masking levels are difficult to predict, and no auditory thresholds exist for masking effects on cetaceans (Erbe *et al*.,2016); however, as outlined above masking responses have been documented to occur at relatively low exposure levels (i.e. lower than what would elicit a behavioural response). It is likely that cetaceans in the vicinity of the Operational Areas during each checkshot survey may be subject to some masking effects, particularly blue whales and southern right whales due to their low frequency calls. However, any masking effects will cease at the completion of each checkshot survey, and based on the short duration of each survey (i.e. approximately 3.8 to 9.3 hours) it is highly unlikely that any masking will have detectable population effects on the cetaceans present in the Taranaki Basin. Overall, the residual risk of perceptual effects on cetaceans has been assessed as **moderate**.

6.2.2.5 Potential Indirect Effects

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

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

In particular, the potential indirect effects on pygmy blue whales in the South Taranaki Bight from changes to krill distribution and abundance must be considered due to the South Taranaki Bight's importance as a foraging ground for pygmy blue whales (Torres *et al*., 2015, **Section 5.2.6.2.6**). McCauley *et al*. (2017) provided evidence to suggest seismic surveys may cause significant mortality of krill larvae. No information is available with regard to how adult krill are affected by seismic surveys, but the mortality of krill larvae as described by McCauley *et al*. (2017) suggests that seismic surveys may alter the distribution and abundance of krill in the vicinity of seismic operations. Although, it is possible that the Taranaki Checkshot Surveys could affect the prey availability of blue whales within the Operational Areas, particularly in the more southern Māui-8 Operational Area, such effects are not expected due to the low levels of sound predicted for each survey. Furthermore, the main aggregations of krill are typically outside of the Operational Areas, to the south-west of the South Taranaki Bight.

In addition to the potential impacts on the distribution and abundance of krill, the distribution and abundance of fish can also change in response to exposure to underwater noise; the potential impacts of disturbance to fish are detailed within **Sections 6.2.2.3.3**. Based on these discussions, indirect effects on predatory fish species and piscivorous marine mammals could occur.

While there is some potential for indirect effects on marine mammals and fish from the Taranaki Checkshot Surveys, there is a general lack of scientific information about such effects. On account of the difficulty to predict with any certainty what indirect effects might occur, the ability to target management measures to avoid, remedy or mitigate indirect effects is also difficult. However, the very short timeframe associated with the Taranaki Checkshot Surveys is a key measure in mitigating any potential indirect effects. Based on this, the residual risk of indirect effects from the Taranaki Checkshot Surveys is assessed as **negligible**.

6.2.3 Waste Discharges and Emissions

The MODU and support vessel will produce wastes during the Taranaki Checkshot Surveys as biodegradable and non-biodegradable wastes, and atmospheric emissions from exhausts.

Inappropriate discharges of these wastes have the potential to cause adverse effects on the surrounding environment. However, given that the volume of waste produced depends predominantly on the number of personnel onboard the vessels and duration of the survey, the volume produced during the checkshot survey period is likely to be small. Wastes produced outside of this period still have the potential to cause adverse effects to the marine environment but are not directly assessed as part of this MMIA.

All produced wastes will be managed in accordance with OMV environmental practices, and MARPOL requirements (as enacted by the Marine Protection Rules).

6.2.3.1 Potential Effects from Biodegradable Waste

Biodegradable wastes likely to be produced on the MODU and support vessel during the checkshot surveys include:

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

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

The following will be followed throughout the duration of the Taranaki Checkshot Surveys to mitigate against adverse effects from the discharge of biodegradable wastes in line with the marine consents for the EAD Programmes:

- Discharges will occur in accordance with the New Zealand Marine Protection Rules;
- Biodegradable wastes will be comminuted to less than 25 mm prior to discharge;
- Sewage and grey water will pass through sewage treatment facilities prior to discharge; and
- Discharges containing oils will pass through onboard treatment systems and will only be discharged when below oil-in-water concentrations of 15 ppm.

The residual risks to the marine environment from routine discharges of biodegradable waste generated by the MODU and support vessel are considered to be **negligible.**

6.2.3.2 Potential Effects from Non-biodegradable Waste

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

All non-biodegradable wastes will be appropriately stored onboard the MODU or support vessel to ensure they cannot escape to the surrounding marine environment and will be returned to shore for disposal in adherence to local waste management requirements. Suitable chain of custody records for all waste sent to onshore processing facilities will be retained.

The residual environmental risk of any non-biodegradable discharges to the marine environment during the Taranaki Checkshot Surveys is considered to be **negligible**.

6.2.3.3 Potential Effects from Atmospheric Emissions

The primary sources of atmospheric emissions during the Taranaki Checkshot Surveys will be the result of exhaust gasses produced by internal combustion engines (e.g. main engines, generators, deck equipment, etc.) onboard the MODU and support vessel. Exhaust emissions will be primarily composed of carbon dioxide and carbon monoxide but will also include small quantities of other toxic inorganic gasses such as nitric oxide and nitrogen dioxide (Steiner *et al*., 2016). Exhaust gasses can reduce the ambient air quality.

Effects of the EAD Programme on human health, including effects from atmospheric emissions were assessed within the EAD Marine Consents as negligible. The Taranaki Checkshot Surveys will not add to this risk, as a result, the residual environmental risk of atmospheric emissions during the Taranaki Checkshot Surveys is considered to be **negligible**.

6.2.4 Cumulative Effects

Cumulative effects can occur where multiple sound sources combine leading to an overall increase in underwater sound levels. Of primary concern for seismic surveys is the potential for cumulative acoustic effects that could result when multiple sources of underwater noise combine to significantly increase the underwater sound profile above its natural baseline level. Assessing cumulative effects in a quantitative manner is fraught with difficulties and therefore few studies have broached this topic in relation to seismic surveys.

Of particular concern is the potential for cumulative noise effects arising from multiple seismic surveys overlapping temporally (i.e. at the same time) or spatially (i.e. over the same area but not necessarily over the same time period). With the exception of the Taranaki Checkshot Surveys, there are no known planned seismic surveys in the offshore Taranaki area in the next 12 – 24-month period, therefore cumulative effects from multiple seismic surveys are not considered further.

Shipping traffic in the surrounding Taranaki Basin is the most likely potential contributor to cumulative effects of underwater noise during the Taranaki Checkshot Surveys. While there are no specifically designated shipping lanes in the offshore Taranaki region, **Section 5.4.2.2** shows the location of the most commonly travelled routes between major ports to/from Port Taranaki and most actively used areas for shipping. Several wells in the Taranaki/Māui EAD Programmes are located within (e.g. Māui-8) or close to (e.g. Toutouwai-1) these shipping areas. As a result, shipping noise is an ongoing, but unquantified component of the sound scape in these areas.

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

Given that the DOC Code of Conduct requirements act to manage the acoustic effects of seismic surveys to 'as low as reasonably practicable', the extremely short duration of the active phase of each checkshot survey, minimal number of acoustic releases required for each survey, and the extended time between each survey (if they occur), the incremental contribution of these surveys to cumulative effects will be limited. Therefore there are no specifically applicable additional mitigation measures available to address cumulative effects.

The residual environmental risk of cumulative effects from the Taranaki Checkshot Surveys across the offshore Taranaki area is considered to be **minor**.

6.3 Unplanned Events

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

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

Some unplanned events (such as biosecurity incursion) are not covered in this document as these issues surrounding the MODU and support vessel involved in the Taranaki Checkshot Surveys were covered in the Marine Consents for the wider Taranaki and Māui EAD Programmes.

6.3.1 Potential Effects of Equipment Loss

The acoustic array proposed to be utilised for the Taranaki Checkshot Surveys will be deployed over the side of the MODU on a crane on a wire cable. In the unlikely event that the acoustic source was lost it would likely rapidly sink to the seabed beneath the position it was deployed from. Upon contacting the seabed, the source could impact benthic communities; however, as can be seen in **Figure 3**, the triple acoustic source cluster is a small, open-framed structure.

The marine consents for the Taranaki and Māui EAD Programmes require that objects that are dropped/fall into the sea will be located by the Remotely Operated Vehicle and retrieved if safely feasible. Any significant objects unable to be recovered must be reported to the EPA and if they remain floating other notifications may be needed (e.g. Maritime New Zealand).

In the event that the source was lost or unable to be retrieved from the seafloor, it is useful to note the benign nature of the offshore Taranaki marine benthic setting, generally lacking sensitive environments, as described in **Section 5.2.3**, whereas areas of archaeological interest or cultural significance in Taranaki are typically associated with intertidal and subtidal coastal environments.

All activities carried out during the Taranaki Checkshot Surveys, including deployment of the acoustic source from the MODU crane, will be undertaken by experienced personnel using lifting equipment that is suitably rated and in current test status. The relatively small physical size of source means the lifting and deployment would not be a difficult deployment for trained crane operators.

It is considered that the residual environmental risk from loss of equipment during the Taranaki Checkshot Surveys would be **negligible**.

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

The potential effects from vessel collision (involving either the support vessel or MODU) or sinking, and subsequent release of hazardous substances carried onboard the MODU/support vessel were assessed in detail within the Marine Consents for the wider Taranaki and Māui EAD Programmes. The Taranaki and Māui Marine Consents assessed the environmental risk associated with a vessel collision as low, and the Taranaki Checkshot Surveys will not add further risk to environmental receptors above what has been assessed within the Marine Consents. However, a brief summary is provided below.

In the event of a vessel collision and possible sinking, the biggest threats to the marine environment would be: the vessel sinking and impacting the seafloor, pollution through the spread of debris, and the release of hazardous substances.

Measures in place to ensure that the risk of vessel collision/sinking and subsequent spills are minimised include:

- The location of the MODU will be supplied to marine users for the duration of the EAD Programme through a Notice to Mariners and coastal navigation warnings. A 500 m exclusion zone will be in place around the MODU;
- A support vessel will be present at all times in close proximity to the MODU;
- The MODU and support vessel will adhere to all relevant safety requirements as per international regulations and conventions (e.g. COLREGS), maintain visual and radar watch for the presence of other vessels, scan and monitor VHF radio, transmit its location using AIS, and will display appropriate day shapes and lights; and
- Spill responses will be undertaken in accordance with the Shipboard Oil Pollution Emergency Plan.

Based on the information presented above and the mitigation actions in place, it is considered that the residual risks of vessel collision/sinking and subsequent release of hazardous substances during the Taranaki Checkshot Surveys are **minor**.

6.4 Environmental Risk Assessment Summary

Table 26 provides a summary of the ERA results.

Table 26 Summary of Potential Residual Effects and Significance

Effects from Planned Activities	Significance
Physical presence of MODU, support vessel and acoustic source – effects on marine mammals.	Negligible
Physical presence of MODU, support vessel and acoustic source – effects on seabirds.	Negligible
Physical presence of MODU, support vessel and acoustic source – effects on other marine users.	Negligible
Acoustic disturbance – physiological effects on zooplankton.	Minor
Acoustic disturbance – physiological effects on benthic invertebrates.	Negligible
Acoustic disturbance – physiological effects on cephalopods.	Negligible
Acoustic disturbance – physiological effects on fish.	Negligible
Acoustic disturbance – physiological effects on marine reptiles.	Negligible
Acoustic disturbance – physiological effects on seabirds.	Negligible
Acoustic disturbance – physiological effects on marine mammals.	Moderate
Acoustic disturbance – behavioural effects on benthic invertebrates.	Negligible
Acoustic disturbance – behavioural effects on cephalopods.	Minor
Acoustic disturbance – behavioural effects on fish and commercial fisheries.	Minor
Acoustic disturbance – behavioural effects on marine reptiles.	Negligible
Acoustic disturbance – behavioural effects on seabirds.	Negligible
Acoustic disturbance – behavioural effects on marine mammals.	Moderate
Acoustic disturbance – perceptual effects on fish.	Minor
Acoustic disturbance – perceptual effects on marine mammals.	Moderate
Acoustic disturbance – indirect effects	Negligible
Waste discharges and emissions – biodegradable waste	Negligible
Waste discharges and emissions – non-biodegradable waste	Negligible
Waste discharges and emissions – atmospheric emissions	Negligible
Cumulative effects	Minor
Effects from Unplanned Events	
Effects from equipment loss	Negligible
Effects from vessel collision or sinking	Minor

7 Conclusion

Checkshot surveys are required to identify specific characteristics within the geological features discovered below the seafloor during the drilling activities associated with the Taranaki and Māui EAD Programmes. Checkshot surveys may be undertaken if hydrocarbon accumulations that are considered to be of potential commercial significance are discovered at Gladstone-1, Toutouwai-1 or Māui-8. During each checkshot survey an acoustic receiver will be lowered down the borehole to receive the sounds emitted from the acoustic source deployed from the side of the MODU, 5 m below the sea surface.

During the Taranaki Checkshot Surveys, OMV will comply with the Code of Conduct as the primary means of mitigating any potential environmental effects arising from the surveys. By committing to the mitigation measures required by the Code of Conduct, the potential effects of acoustic disturbance on marine mammals will be minimised to a level that is deemed acceptable by DOC. In order to ensure compliance with the standard mitigation zones, STLM has been conducted, ensuring that the mitigation zones are sufficiently large to protect marine mammals from physiological, behavioural and perceptual effects during the Taranaki Checkshot Surveys. The STLM short-range modelling prediction demonstrates that for all of the initial three proposed well locations, the maximum received SELs are predicted to comply with the 186 dB re 1µPa^2·s at 200 m, and 171 dB re 1µPa^2·s at 1.0 km and 1.5 km.

As per the Code of Conduct, there will be two MMOs on the MODU for daytime observations and two PAM Operators onboard the support vessel to provide 24-hour coverage with acoustic detections. These personnel will be independent and qualified through DOC approved training programmes. Visual and acoustic watch will be maintained around the clock, including during the required pre-startup observation period. Detections of marine mammals within the mitigation zones will trigger the required mitigation action (e.g. delayed starts or shut-downs of the acoustic source).

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

- Compliance with all required and relevant regulations and conventions (e.g. COLREGS and MARPOL) to ensure safety of all crew and other marine users and to avoid adverse effects on the marine environment from potential discharges and vessel collisions;
- Compliance with the Code of Conduct including the following key points:
  - Two MMOs will be stationed onboard the MODU to maintain visual watch and two PAM Operators will be deployed onboard the support vessel to maintain acoustic watch with the PAM system. While it is preferred that MMOs and PAM Operators are trained and qualified, the Code of Conduct provides for a qualified MMO and PAM Operator to act as a supervisor/mentor. At a minimum there will be one qualified observer and one trained observer in each observation role (MMO or PAM Operator). The support vessel will circle the MODU at a radius of approximately 1 km;
  - The standard mitigation zones within the Code of Conduct will be used for delayed starts and shut-downs. STLM has confirmed that the survey complies with the regulatory mitigation zone SEL requirements defined within the Code of Conduct;

- Pre-start observations will be carried out for at least 30 minutes prior to activating the acoustic source. The acoustic source will only be activated in the event that no marine mammals (other than New Zealand fur seals) have been observed in the relevant mitiagation zone for at least 30 minutes, and no New Zealand fur seal has been observed in the relevant mitigation zone for at least 10 minutes;
- Additional observation requirements for start-up in a new location in poor sighting conditions will be followed at the commencement of each new checkshot survey (i.e. at Gladstone-1, Toutouwai-1, and Māui-8);
- If a marine mammal is observed within the relevant mitigation zone, the acoustic source will be shut-down or start-up will be delayed until the MMOs confirm the animal has left the mitigation zone for the required period of time; and
- Activation of the acoustic source will only occur following the soft-start procedures after the above observation period.

In addition to the above mitigation measures, the following will be undertaken as required throughout the duration of the Taranaki Checkshot Surveys:

- Immediate notification to DOC of any Hector's/Māui's dolphin sightings; and
- In the event that a stranding occurs during the checkshot surveys, or within two weeks following the completion of each survey 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 will seek advice from DOC as to the requirement for a necropsy.

Overall, the predicted effects of the Taranaki Checkshot Surveys are considered to be sufficiently managed by the proposed mitigation measures, predominantly compliance with the Code of Conduct. Due to the small volume acoustic source that will be utilised during each survey, behavioural effects on marine mammals will be restricted to within 200 m of the acoustic source, as demonstrated by STLM. Masking of animal vocalisations may occur; however, the short duration of each survey reduces the possibility of this masking having long-term effects. Discharges associated with the MODU and support vessel, the presence of these vessels within each Operational Area, and the potential for interactions with other marine users have been covered under the appropriate Marine Consents for the Taranaki and Māui EAD Programmes.

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APPENDIX A

Sound Transmission Loss Modelling Report

TARANAKI AND MĀUI EAD CHECKSHOT SURVEYS

Sound Transmission Loss Modelling

Prepared for:

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SLR

SLR Ref: 740.10078.0100-R01
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BASIS OF REPORT

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

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

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

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078.0100-R01-v1.0	31 October 2019	[redacted]	[redacted]	[redacted]
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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by OMV New Zealand Limited (OMV) and OMV Taranaki Limited (OTL) to provide Sound Transmission Loss Modelling (STLM) for the checkshot surveys (should they be required) at the three proposed exploration wells, namely Gladstone-1, Toutouwai-1 and Māui-8. The checkshot surveys will only be undertaken at these wells in the event that hydrocarbon accumulations are discovered, and this STLM is to assist with undertaking these activities in accordance with the relevant regulatory requirements.

This report details the STLM that has been carried out for the proposed checkshot surveys, which includes the following two modelling components:

- Array source modelling – i.e. modelling the sound energy emissions from the array source, including its directivity characteristics; and
- Short range modelling – i.e. prediction of the received sound exposure levels (SELs) over a range of a few kilometres from the array source location, in order to assess whether the proposed survey complies with the regulatory mitigation zone requirements.

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

The source array proposed for the checkshot surveys is the 450 cubic inch triple G-Gun source cluster array which will be deployed from a crane over the side of the Mobile Offshore Drilling Unit (MODU), approximately 5.0 m below the water surface. The cluster has an operating pressure of 2,000 pounds per square inch (PSI).

The array source modelling illustrates strong array directivity which has significant angle and frequency dependence for the energy radiation from the array as a result of interference between signals from different array elements. The short range modelling prediction demonstrates that the highest SELs occur in the directions perpendicular to the cluster frame plane as a result of the directivity of the source cluster array.

The short range modelling prediction demonstrates that for all three well locations, the maximum received SELs over all azimuths are predicted to comply with:

- the threshold level of 186 dB re 1µPa^2·s at 200 m; and
- the threshold level of 171 dB re 1µPa^2·s at 1.0 km and 1.5 km.

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APPENDICES

1 Introduction

1.1 Background

OMV New Zealand Limited and OMV Taranaki Limited (collectively referred to as OMV) will be undertaking the Taranaki Exploration and Appraisal Drilling (EAD) Programme within the Taranaki Basin from 2019. The purpose of these EAD Programmes is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the potential for future development of discovered hydrocarbons within OMV's permit areas.

Drilling activities associated with the Taranaki EAD Programme will be undertaken within Petroleum Exploration Permit (PEP) 57075 and 60093 (i.e. Gladstone-1 and Toutouwai-1 respectively). All drilling activities associated with the Māui EAD Programme will be undertaken within Petroleum Mining Licence (PML) 381012.

Checkshot surveys will be undertaken if hydrocarbon accumulations are discovered at Gladstone-1, Toutouwai-1, or Māui-8. In the event that no hydrocarbon accumulations are discovered, no checkshot survey is likely to be required. The objective of the Taranaki Checkshot Surveys is to ascertain further information about the structure/strata where a commercial hydrocarbon accumulation has been identified, and the surrounding structures. The Gladstone-1, Toutouwai-1 and Māui-8 wells are located in the Taranaki Bight in water depths of 135 m, 131 m, and 110 m respectively. Planned well characteristics for each well are provided in **Table 1** below.

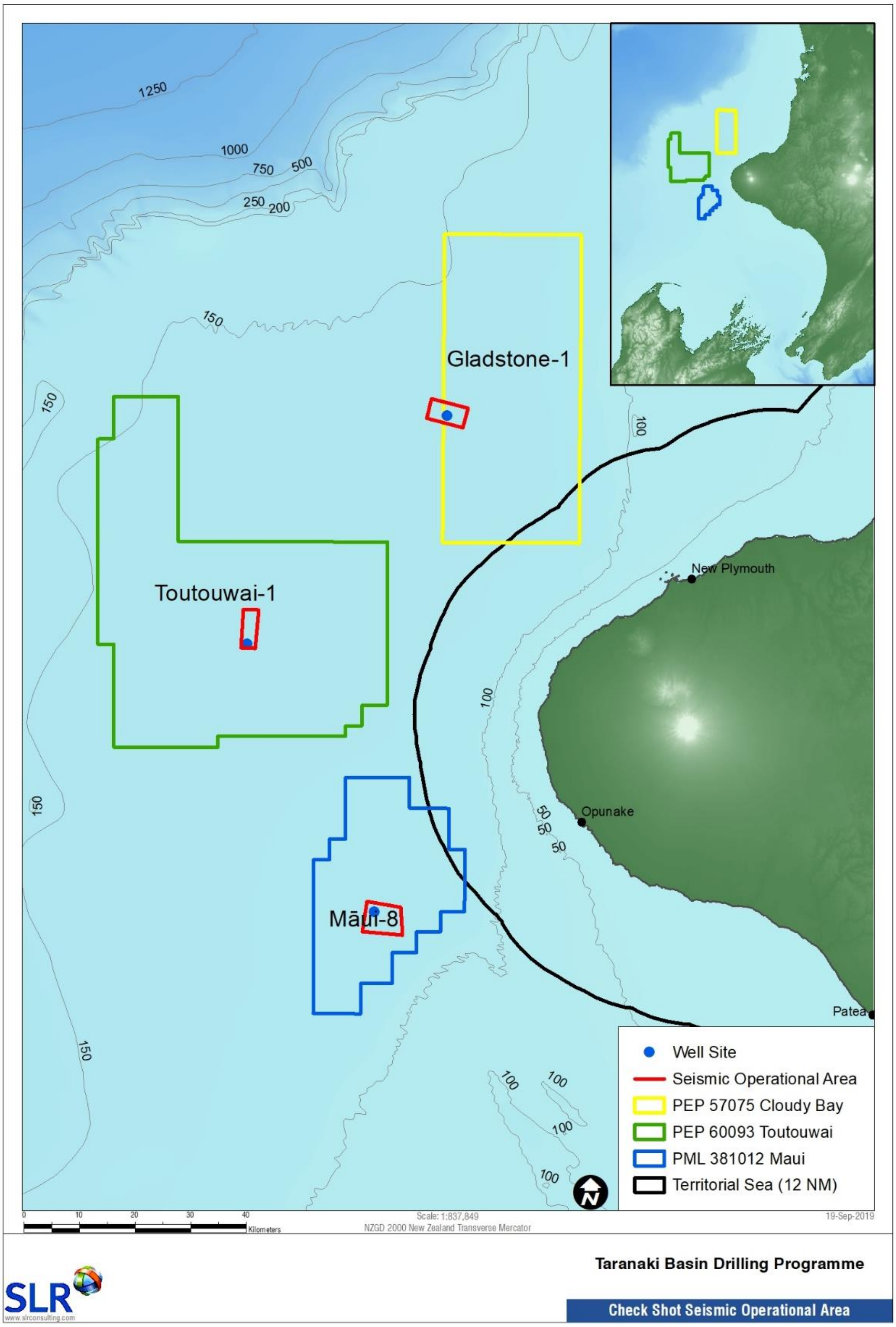
Table 1 Planned Well Characteristics for Gladstone-1, Toutouwai-1 and Māui-8 wells

Well	Water Depth (m bMSL)	Target Depth (m)	Last Casing Depth (m)	Length of Open Hole (m)
Gladstone-1	135	3,079	1,515	1,550
Toutouwai-1	131	4,361	1,520	2,841
Māui-8	110	3,410	1,100	2,310

As shown in **Figure 1**, the three wells have a geographic distribution across the North and South Taranaki Bight, and three Operational Areas were defined, which is the area where the acoustic source can be active, and is also the area which was assessed during the preparation of the Marine Mammal Impact Assessment (MMIA).

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

Figure 1 Location of Gladstone-1, Toutouwai-1 and Māui-8 wells and Associated Operational Areas



1.2 Statutory requirements for sound transmission loss modelling (STLM)

The Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) came into force in 2013 and established the first comprehensive environmental consenting regime for activities in New Zealand's Exclusive Economic Zone (EEZ) and Continental Shelf. Under the EEZ Act, a marine seismic survey is classified as a permitted activity and is therefore covered under the Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013 (Permitted Activities Regulations). The Permitted Activities Regulations permit seismic surveys providing the operator undertaking the survey complies with the Department of Conservation (DOC) 2013 Code or obtains a marine consent from the EPA.

When a seismic survey is conducted within an Area of Ecological Importance, the Code requires STLM to be undertaken to determine whether received sound exposure levels (SELs) from the checkshot surveys exceed 171 dB re 1μPa^2·s (the behaviour criteria) at ranges of 1.0 km and 1.5 km from the source (for species of concern with and without calf present respectively) or 186 dB re 1μPa^2·s (the injury criteria) at a range of 200 m from the source.

1.3 Structure of the report

This STLM study includes the following two modelling components:

- Array source modelling, i.e. modelling the sound energy emissions from the checkshot survey array source, including its directivity characteristics; and
- Short range modelling, i.e. prediction of the received SEL over a range of a few kilometres from the array source location, in order to assess whether the proposed checkshot surveys comply with the near-field mitigation zone requirements imposed by the Code.

Section 2 of this report details the modelling methodology, procedure and results for the array source modelling. **Section 3** of the report outlines the methodology and procedure associated with the short range transmission loss modelling, with the major modelling results presented in **Section 4**. Relevant acoustic terminologies throughout the report are presented in **Appendix 1**.

2 Checkshot Survey Array Source Modelling

2.1 Source array configuration

The source array proposed for the checkshot surveys is three 150 cubic inch guns mounted on a triple G-Gun source cluster, giving a toal volume of 450 cubic inches as shown within the standard Delta deployment frame in **Figure 2**. The centre of the source array will be located approximately 5.0 m below the water surface, which will be deployed from a crane onboard the Mobile Offshore Drilling Unit (MODU), and the cluster has an operating pressure of 2,000 pounds per square inch (PSI).

Figure 2 The 450 cubic inch triple G-Gun cluster inside standard Delta deployment frame (image courtesy of Schlumberger)

2.2 Modelling methodology

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

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

2.2.1 Notional signatures

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

Notional signatures are modelled using the Gundalf Designer software package (2018). The Gundalf array source model is developed based on the fundamental physics of the oscillation and radiation of source bubbles as described by Ziolkowski (1970), taking into account non-linear pressure interactions between 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 sources and interacting cluster sources for all common source types at a wide range of deployment depths.

2.2.2 Farfield signatures

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

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

2.2.3 Beam patterns

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

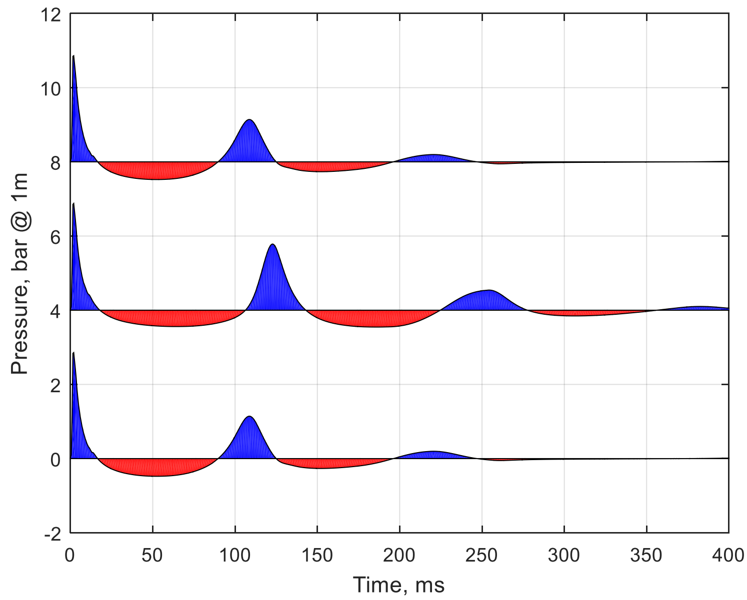
- The farfield signatures are calculated for all directions from the source using azimuthal and dip angle increments of 1-degree;
- The power spectral density (PSD) (dB re 1 µPa^{2}s/Hz @ 1m) for each pressure signature waveform is calculated using a Fourier transform technique; and
- The PSDs of all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

2.3 Modelling results

2.3.1 Notional signatures

Figure 3 shows the notional signatures for the 3 G-Gun sources of the 450 cubic inch source cluster.

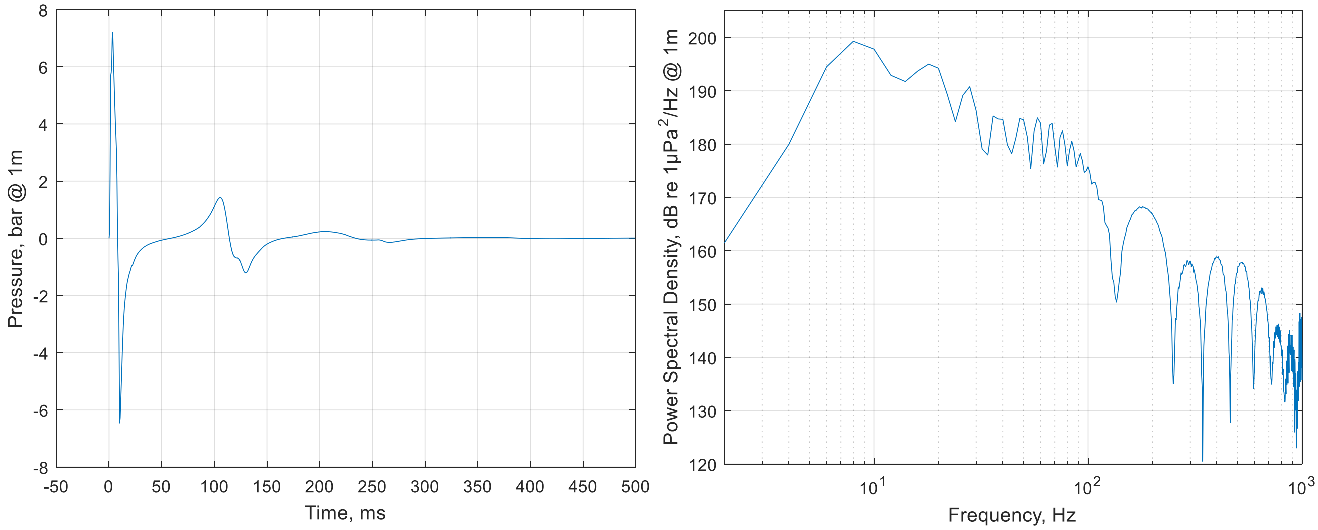
Figure 3 Notional source signatures for the three G-Gun sources of the 450 cubic inch source cluster. Time series of positive pressure and negative pressure indicated by blue fill and red fill respectively. The scale is the same for the signatures from all sources.



2.3.2 Farfield signatures

Figure 4 shows the simulated signature waveform and its power spectral density based on Gundalf Designer software. The signature is for the vertically downward direction with surface ghost included.

Figure 4 The farfield signature of vertically downward direction (left) and the power spectral density (right) for the 450 cubic inch G-Gun cluster.



The source modelling result shows that the peak sound pressure level (Pk SPL) is 7.3 bar (237.4 dB re 1 μPa @ 1m), the peak to peak sound pressure level (Pk-Pk SPL) 14.1 bar (243.0 dB re 1 μPa) @ 1m, the root-mean-square sound pressure level (RMS SPL) 225.2 dB re 1 μPa @ 1m with a 90%-energy pulse duration of 100 milliseconds, and the sound exposure level (SEL) 215.7dB re μPa^2·s @ 1m.

2.3.3 Beam patterns

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

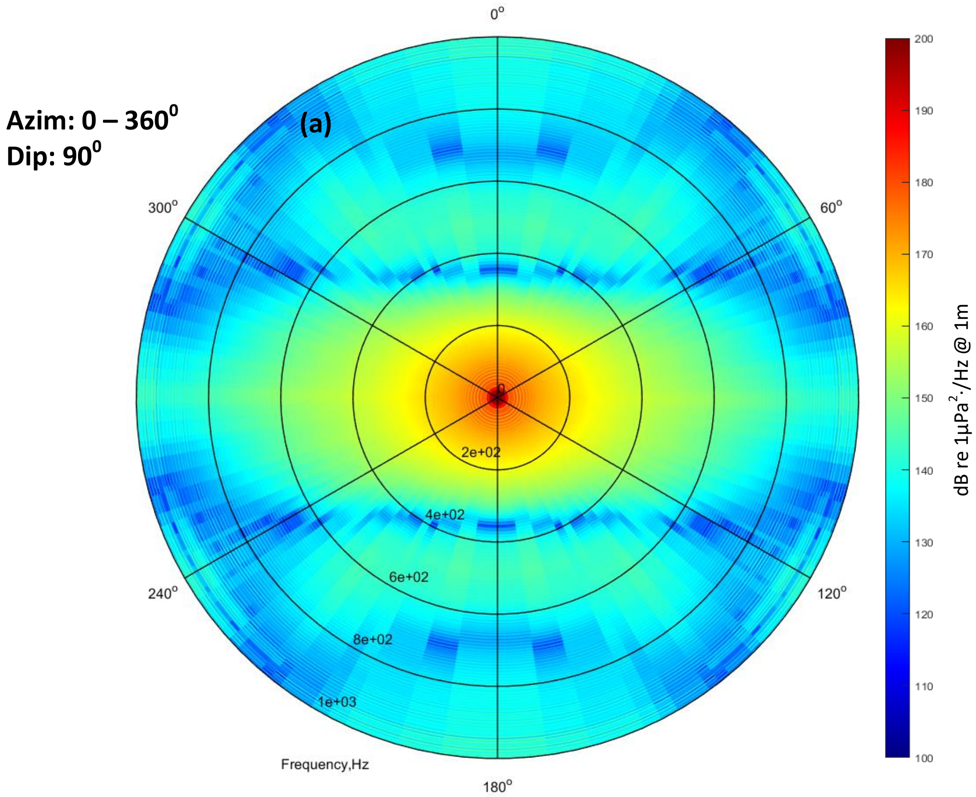
a) The horizontal plane (i.e. dip angle of 90 degrees) with azimuthal angle of 0 degree corresponding to the direction in parallel with the cluster frame plane;

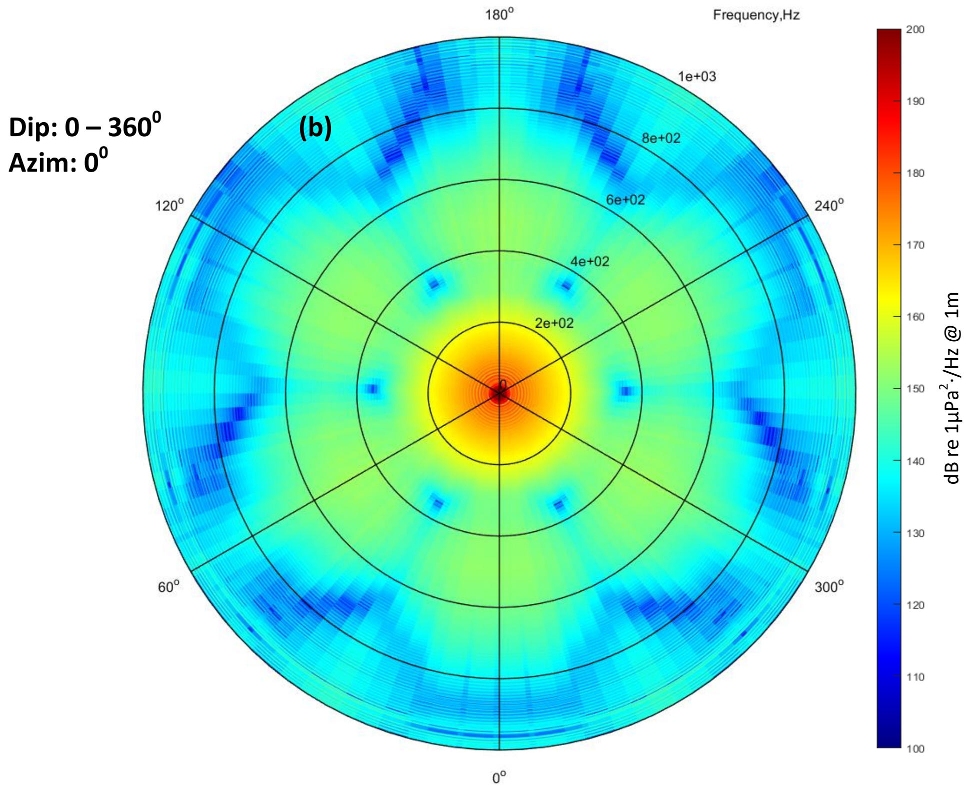
b) The vertical plane in parallel with the cluster frame plane (i.e. azimuthal angle of 0 degree) with dip angle of 0 degree corresponding to the vertically downward direction; and

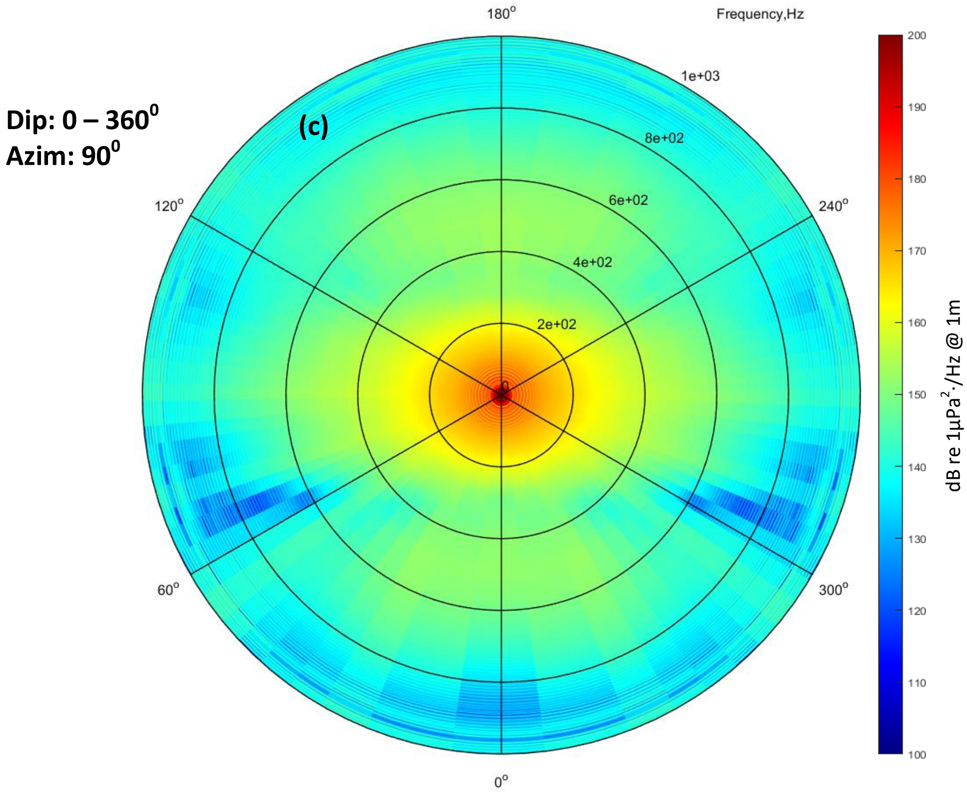
c) The vertical plane perpendicular to the cluster frame plane (i.e. azimuthal angle of 90 degrees) with dip angle of 0 degree corresponding to the vertically downward direction.

These beam patterns illustrate the strong angle and frequency dependence of the energy radiation from the array, as a result of interference between signals from different array elements.

Figure 5 Array farfield beam patterns as a function of orientation and frequency. (a) – The horizontal plane; (b & C) – The vertical planes in parallel with and perpendicular to the cluster frame plane respectively. 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
0
120°
240°
60°
300°
0°
200
190
180
170
160
150
140
130
120
110
100
dB re 1μPa²·/Hz @ 1m


Dip: 0 – 360⁰
Azim: 90⁰
(c)
180°
Frequency,Hz
1e+03
8e+02
6e+02
4e+02
2e+02
0
120°
240°
60°
300°
0°
200
190
180
170
160
150
140
130
120
110
100
dB re 1μPa²·/Hz @ 1m

3 Transmission loss modelling

3.1 Modelling input parameters

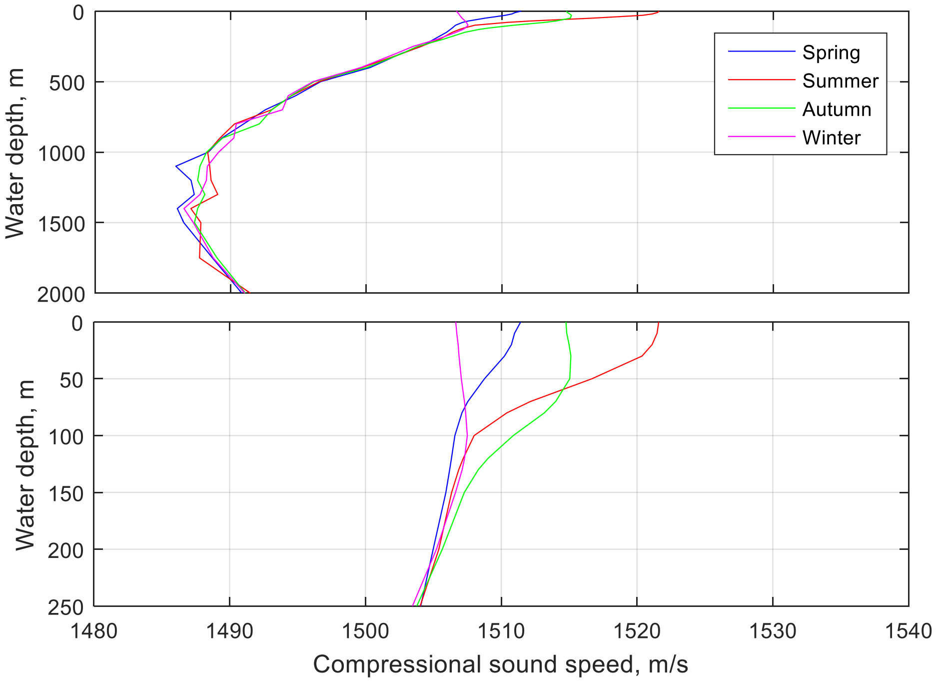
3.1.1 Sound speed profiles

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 needed for calculation of the sound speed based on depth and latitude of each particular sample was obtained using Sanders and Fofonoff's formula (Sanders and Fofonoff, 1976). The sound speed profiles were derived based on Del Grosso's equation (Del Grosso, 1974).

Figure 6 demonstrates typical sound speed profiles within the Taranaki Basin for four southern hemisphere seasons. The most significant distinctions for the four profiles occur within the mixed layer near the sea 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 source array as it is a near-surface acoustic source. In a descending order, the autumn, spring and summer seasons are expected to have relatively weaker sound propagation for a near-surface source array source.

Based on a conservative consideration, the winter sound speed profile is selected as the worst case condition for all sound propagation modelling scenarios.

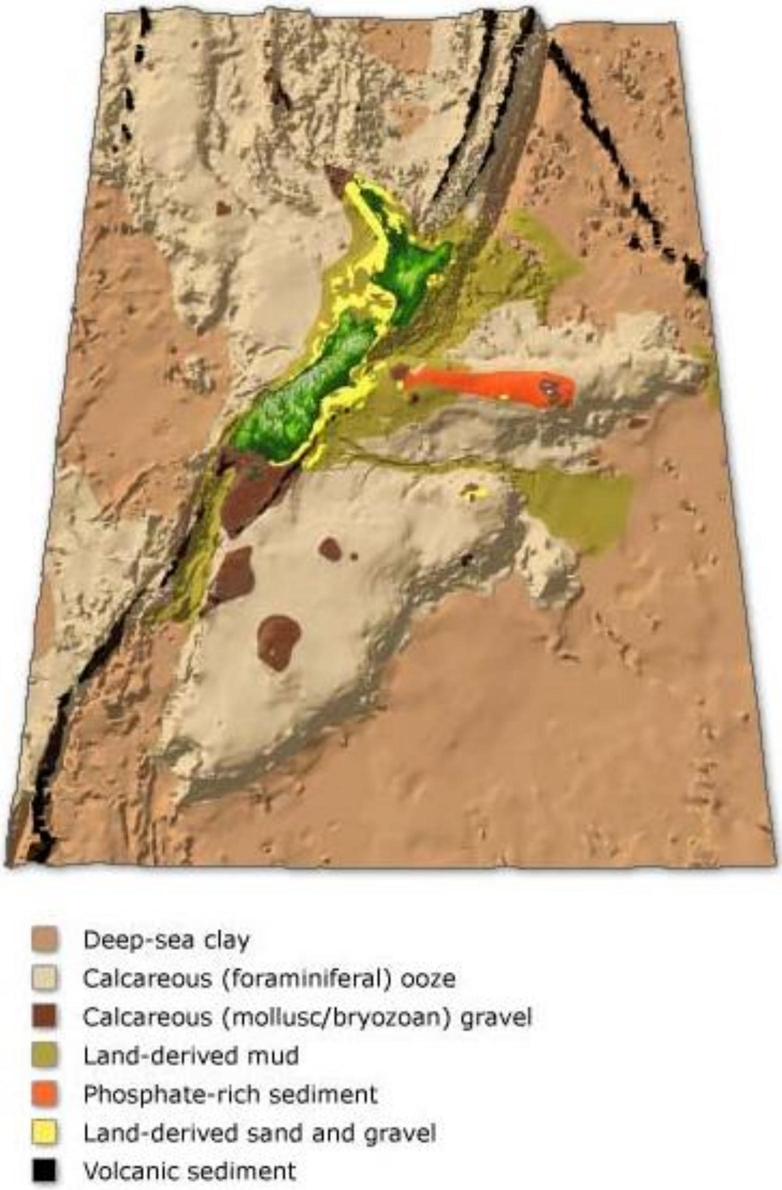
Figure 6 Typical sound speed profiles within the Taranaki Basin for different southern hemisphere seasons. Top panel shows profiles in deep water region, bottom panel shows profiles in continental shelf.



3.1.2 Seafloor geoacoustic models

New Zealand has diverse seafloor sediments thanks to its variable and dynamic marine and terrestrial environments. NIWA has over many years produced a variety of marine sediment charts illustrating the ocean bottom types around coastal New Zealand and some offshore areas. The map in **Figure 7** 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 7 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.

The detailed sediment types for various relevant coastal and offshore regions are referred to the New Zealand marine sediment charts and some technical reports (e.g. such as Matthew et al., 2014 and Galindo-Romero et al., 2014). A summary of sediment types in and around the Taranaki Basin is provided in **Table 2**.

Table 2 Detailed sediment types within the coastal and offshore regions

Region - West New Zealand	Sediment Type
Taranaki – Northland Continental Shelf	Dominant fine sand sediment with coarse sand sparsely scattered
Taranaki – Northland Continental Slope	Silt - clay
Southern New Caledonia Basin, Reinga Basin and Challenger Plateau	Pelagic sediments (mud – oozes, equivalent to silty clay)
Cook Strait	Fine sand

The geoacoustic properties for the various possible sediment types within the coastal and offshore regions are presented in **Table 3**. 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 3 Geoacoustic properties for various possible sediment types within the coastal and offshore regions in the Taranaki Basin

Sediment Type	Density, ρ, ($kg.m^{-3}$)	Compressional Wave Speed, c_p, ($m.s^{-1}$)	Compressional Wave attenuation, α_p, (dB/λ)
Sand			
Coarse Sand	2,035	1,835	0.8
Fine Sand	1,940	1,750	0.8
Very Fine Sand	1,855	1,700	0.8
Silt - Clay			
Silt	1,740	1,615	1.0
Sand-Silt-Clay	1,595	1,580	0.4
Clayey Silt	1,490	1,550	0.2
Silty Clay	1,420	1,520	0.2

The reflection coefficients for sediments of sand, silt and clay are presented in **Figure 8** and **Figure 9** respectively. As can be seen, the sandy seafloor sediments are more reflective than the silt and clay sediments, particularly at low grazing angles.

Figure 8 Reflection coefficients (magnitude - top panel and phase – bottom panel) for sand sediments (coarse sand, fine sand and very fine sand)

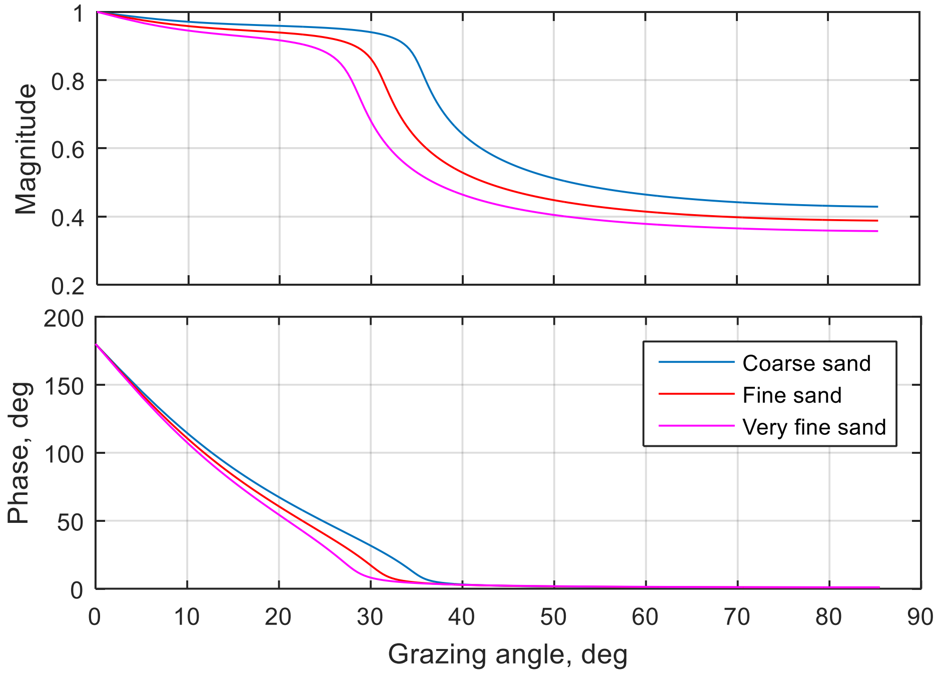
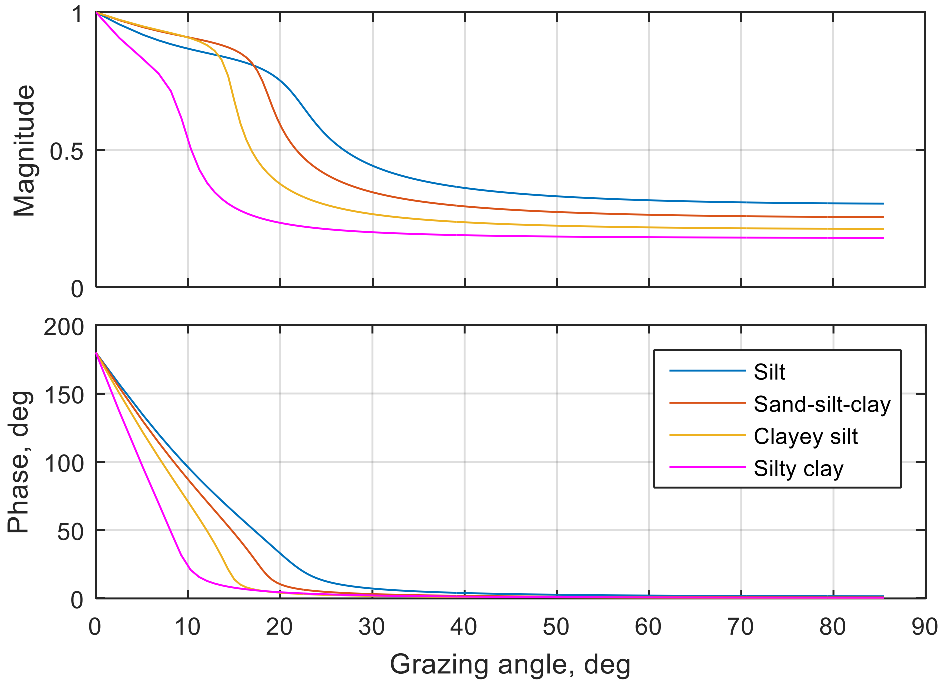


Figure 9 Reflection coefficient (magnitude - top panel and phase – bottom panel) for silt-clay sediments (silt, sand-silt-clay, clayey silt, silty clay)



3.2 Short range modelling - methodologies and procedures

3.2.1 Modelling methodology and procedure

The short range modelling is used to verify mitigation zones in relatively close proximity to the source array, and requires modelling predictions with high accuracy. In addition, interference between the signals arriving at any receiving location from different sources in the source 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 simulating the received signal waveforms from individual source units within the array.

The wavenumber integration modelling algorithm SCOOTER (Porter, 2010) is used to calculate the transfer functions (both amplitudes and phases) between sources and receivers. SCOOTER is a finite element code for computing acoustic fields in range-independent environments. The method is based on direct computation of the spectral integral, and is capable of dealing with an arbitrary layered seabed with both fluid and elastic characteristics.

The following procedures have been followed to calculate received SELs for short range cases:

1. The modelling algorithm SCOOTER is executed for frequencies from 1 Hz to 1 kHz, in 1 Hz increments. The source depth is taken to be the array depth of 5.0 m. A receiver grid of 1 m in range (maximum range 4.0 km) and 1 m in depth is applied for the selected receivers. For each gridded receiver, the received SEL is calculated by following steps 2) – 5);
2. The range from the source to each receiver is calculated, and the transfer function between the source and the receiver is obtained by interpolation of the results produced by modelling algorithm SCOOTER in Step 1). This interpolation involves both amplitude and phase of the signal waveform in frequency domain;
3. The complex frequency domain signal of the notional signature waveform for each source element is calculated via Fourier Transform, and multiplied by the corresponding transfer function from Step 2) to obtain the frequency domain representation of the received signal from the source element;
4. The waveform of received signal from the array source is reconstructed via Inverse Fourier Transform. The received signal waveforms from all airgun sources in the array are summed to obtain the overall received signal waveform; and
5. The signal waveform is squared and integrated over time to obtain the received SEL value. Alternatively, the SEL value can also be calculated via integration of the energy power density (ESD) over frequency in Step 3).

3.2.2 Modelling scenarios

Three short range modelling scenarios will be conducted for the three proposed exploration wells with potential checkshot surveys as shown in **Figure 1,** with their well characteristics for each well are provided in **Table 1**, including their water depths.

The worst-case modelling conditions for underwater noise propagation applicable to the proposed checkshot surveys (i.e., sandy seabed sediment and winter sound speed profile) have been assumed for all the short range modelling cases.

4 Short range modelling results

The received SELs from the 450 cubic inch G-Gun cluster array for the worst-case modelling scenario (i.e. winter season sound speed profile and sandy seabed properties) at the three checkshot survey locations have been calculated. Modelling results are outlined in detail in the following sections.

4.1 Gladstone-1

For the well location Gladstone-1, the maximum received SELs across the water column are presented as a function of azimuth and range from the centre of the array in **Figure 10**. The figure illustrates relatively higher SELs in directions perpendicular to the cluster frame plane as a result of the directivity of the source array.

The scatter plot of the predicted maximum SEL across the water column from the source array for all azimuths is displayed in **Figure 11** 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).

As can be seen from **Figure 11** and **Table 4**, the maximum received SELs over all azimuths are predicted to be 169.9 dB re 1µPa^2·s at 200 m, 157.0 dB re 1µPa^2·s at 1.0 km and 153.5 dB re 1µPa^2·s at 1.5 km. These values are significantly lower than their corresponding mitigation threshold levels. As presented in **Table 5**, the received SELs are predicted to equal the threshold values of 186 dB re 1µPa^2·s and 171dB re 1µPa^2·s at ranges of 22.1 m and 160.0 m respectively.

Figure 10 The predicted maximum received SELs across the water column from the 450 cubic inch array as a function of azimuth and range from the centre of the array. 0 degree azimuth corresponds to the direction in parallel with the cluster frame plane. The modelling scenario is for the well location Gladstone-1 with a water depth 135 m. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

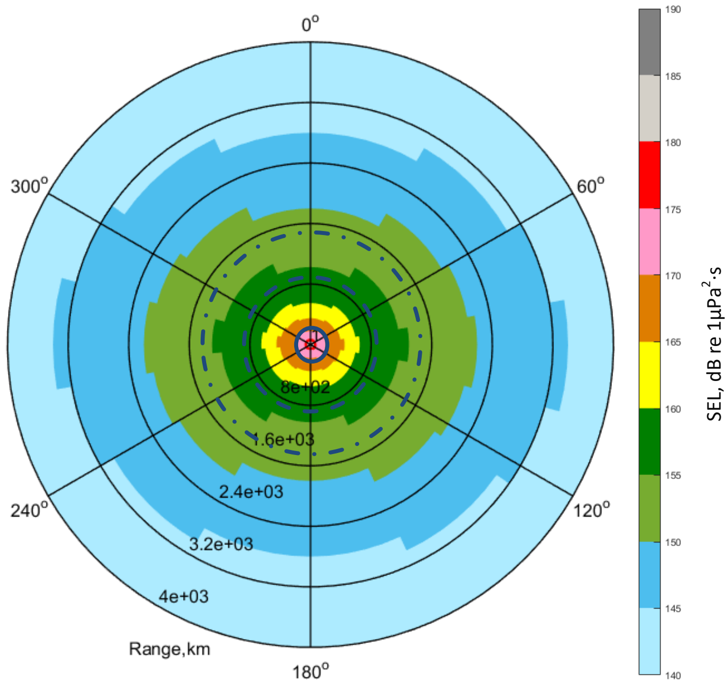


Figure 11 Scatter plot of predicted maximum SELs across the water column from the 450 cubic inch G-Gun cluster source array for all azimuths as a function of range from the centre of the source array. The modelling scenario is for the well location Gladstone-1 with a water depth 135 m. Horizontal red lines show mitigation thresholds of 186 dB re 1µPa²·s (solid) and 171 dB re 1µPa²·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

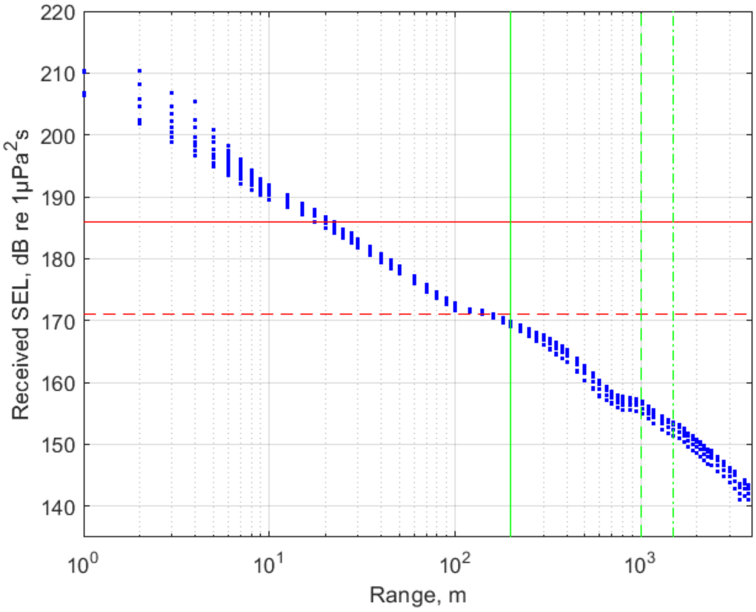


Table 4 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the 450 cubic inch G-Gun cluster array for the well location Gladstone-1 with a water depth 135 m

Source location	Water depth, m	SELs at different ranges, dB re 1µPa²·s		
		200 m	**1.0 km**	**1.5 km**
Gladstone-1	135	169.9	157.0	153.5

Table 5 Ranges from the centre of the array where the predicted maximum SELs for all azimuths equals the SEL threshold levels for the 450 cubic inch G-Gun cluster array for the well location Gladstone-1 with a water depth 135 m

Source location	Water depth, m	Ranges complying with the following SEL thresholds, m	
		SEL < 186 dB re 1µPa²·s	SEL < 171 dB re 1µPa²·s
Gladstone-1	135	22.1	164.0

4.2 Toutouwai-1

For the well location Toutouwai-1, the maximum received SELs across the water column are presented as a function of azimuth and range from the centre of the array in **Figure 12**. The figure illustrates relatively higher SELs in directions perpendicular to the cluster frame plane as a result of the directivity of the source array.

The scatter plot of the predicted maximum SEL across the water column from the source array for all azimuths is 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).

As can be seen from **Figure 12** and **Table 6**, the maximum received SELs over all azimuths are predicted to be 170.1 dB re 1µPa^2·s at 200 m, 157.1 dB re 1µPa^2·s at 1.0 km and 153.7 dB re 1µPa^2·s at 1.5 km. These values are significantly lower than their corresponding mitigation threshold levels. As presented in **Table 7**, the received SELs are predicted to equal the threshold values of 186 dB re 1µPa^2·s and 171dB re 1µPa^2·s at ranges of 22.2 m and 166.5 m respectively.

Figure 12 The predicted maximum received SELs across the water column from the 450 cubic inch array as a function of azimuth and range from the centre of the array. 0 degree azimuth corresponds to the direction in parallel with the cluster frame plane. The modelling scenario is for the well location Toutouwai-1 with a water depth 131 m. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

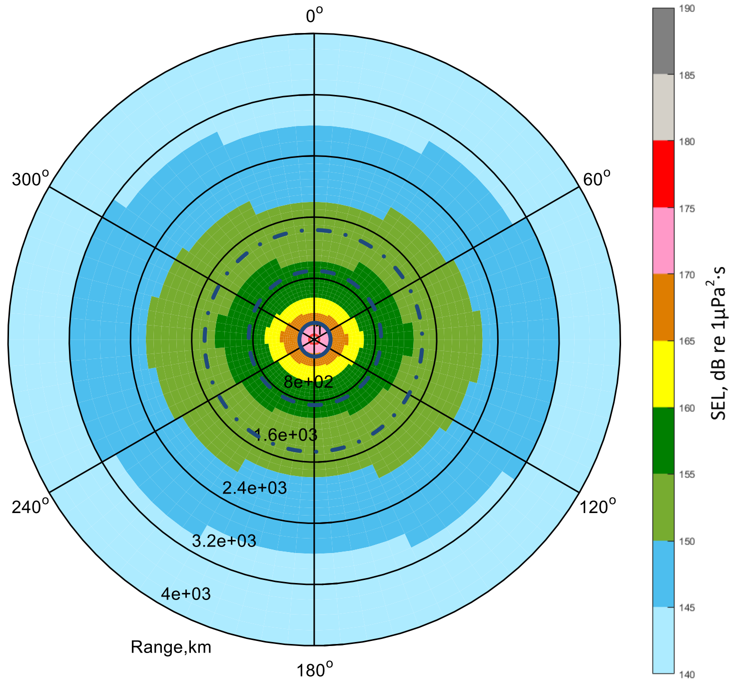


Figure 13 Scatter plot of predicted maximum SELs across the water column from the 450 cubic inch G-Gun cluster source array for all azimuths as a function of range from the centre of the source array. The modelling scenario is for well location Toutouwai-1 with a water depth 131 m. Horizontal red lines show mitigation thresholds of 186 dB re 1μPa²·s (solid) and 171 dB re 1μPa²·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

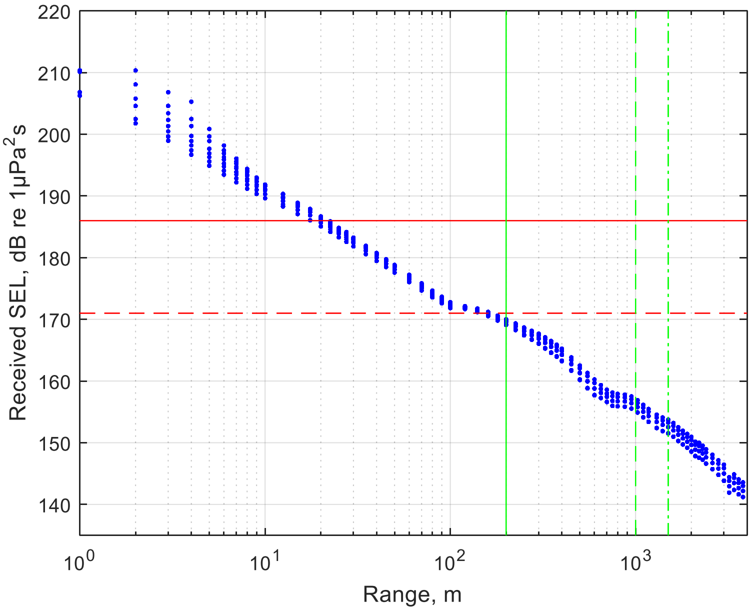


Table 6 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the 450 cubic inch G-Gun cluster array for the well location Toutouwai-1 with a water depth 131 m

Source location	Water depth, m	SELs at different ranges, dB re 1μPa²·s		
		200 m	1.0 km	1.5 km
Toutouwai-1	131	170.1	157.1	153.7

Table 7 Ranges from the centre of the array where the predicted maximum SELs for all azimuths equals the SEL threshold levels for the 450 cubic inch G-Gun cluster array for the well location Toutouwai-1 with a water depth 131 m

Source location	Water depth, m	Ranges complying with the following SEL thresholds, m	
		SEL < 186 dB re 1μPa²·s	SEL < 171 dB re 1μPa²·s
Toutouwai-1	131	22.2	166.5

4.3 Māui-8

For the well location Māui-8, the maximum received SELs across the water column are presented as a function of azimuth and range from the centre of the array in **Figure 14**. The figure illustrates relatively higher SELs in directions perpendicular to the cluster frame plane as a result of the directivity of the source array.

The scatter plot of the predicted maximum SEL across the water column from the source array for all azimuths is displayed in **Figure 15** 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).

As can be seen from **Figure 14** and **Table 8**, the maximum received SELs over all azimuths are predicted to be 170.4 dB re 1µPa^2·s at 200 m, 157.2 dB re 1µPa^2·s at 1.0 km and 154.0 dB re 1µPa^2·s at 1.5 km. These values are significantly lower than their corresponding mitigation threshold levels. As presented in **Table 9**, the received SELs are predicted to equal the threshold values of 186 dB re 1µPa^2·s and 171dB re 1µPa^2·s at ranges of 22.2 m and 181.4 m respectively.

Figure 14 The predicted maximum received SELs across the water column from the 450 cubic inch array as a function of azimuth and range from the centre of the array. 0 degree azimuth corresponds to the direction in parallel with the cluster frame plane. The modelling scenario is for the well location Māui-8 with a water depth 110 m. Dark blue circles represent the mitigation zones of 200 m (solid), 1.0 km (dash) and 1.5 km (dash-dot).

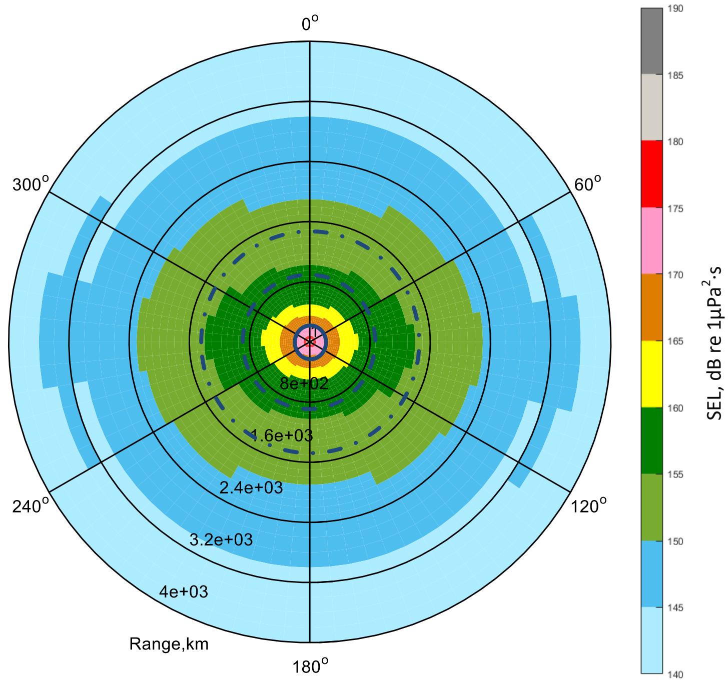


Figure 15 Scatter plot of predicted maximum SELs across the water column from the 450 cubic inch G-Gun cluster source array for all azimuths as a function of range from the centre of the source array. The modelling scenario is for the well location Māui-8 with a water depth 110 m. Horizontal red lines show mitigation thresholds of 186 dB re 1µPa²·s (solid) and 171 dB re 1µPa²·s (dash). Vertical green lines show mitigation ranges of 200 m (solid), 1 km (dash) and 1.5 km (dash-dot).

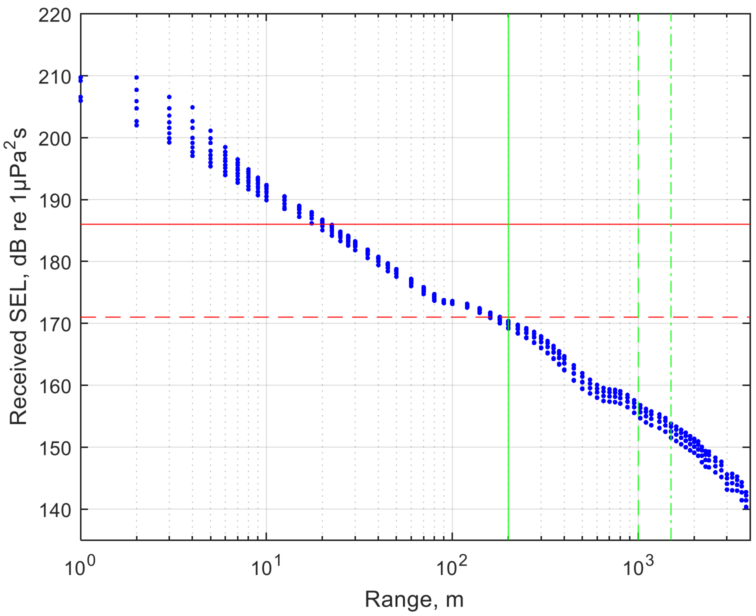


Table 8 Predicted maximum SELs for all azimuths at ranges of 200 m, 1 km and 1.5 km from the centre of the 450 cubic inch G-Gun cluster array for the well location Māui-8 with a water depth 110 m

Source location	Water depth, m	SELs at different ranges, dB re 1µPa²·s		
		200 m	1.0 km	1.5 km
Māui-8	110	170.4	157.2	154.0

Table 9 Ranges from the centre of the array where the predicted maximum SELs for all azimuths equals the SEL threshold levels for the 450 cubic inch G-Gun cluster array for the well location Māui-8 with a water depth 110 m

Source location	Water depth, m	Ranges complying with the following SEL thresholds, m	
		SEL < 186 dB re 1µPa²·s	SEL < 171 dB re 1µPa²·s
Māui-8	110	22.2	181.4

5 Conclusions

This report details the STLM study that has been carried out for the proposed checkshot surveys at the three exploration wells OMV is proposing to drill as part of the Taranaki and Māui EAD Programmes. The modelling study includes two modelling components, e.g. array source modelling and short range modelling. The detailed modelling methodologies and procedures for the two components are described in **Section 2** and **Section 3** of this report.

The short-range modelling prediction demonstrates that for all three well locations, the maximum received SELs over all azimuths are predicted to comply with the thresholds stipulated within the Code, which are:

- 186 dB re 1µPa^2·s at 200 m, and
- 171 dB re 1µPa^2·s at 1.0 km and 1.5 km.

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APPENDIX 1

Acoustic Terminology

Sound Pressure	A deviation from the ambient hydrostatic pressure caused by a sound wave
Sound Pressure Level (SPL)	The logarithmic ratio of sound pressure to the reference pressure. The reference pressure underwater is P_{ref} = 1 µPa
Root-Mean-Square Sound Pressure Level (RMS SPL)	The mean-square sound pressure is the average of the squared pressure over the pulse duration. The root-mean-square sound pressure level is the logarithmic ratio of the root of the mean-square pressure to the reference pressure. Pulse duration is taken as the duration between the 5% and the 95% points on the cumulative energy curve
Peak Sound Pressure Level (Peak SPL)	The peak sound pressure level is the logarithmic ratio of the peak pressure over the impulsive signal event to the reference pressure
Peak-to-Peak Sound Pressure Level (Peak-Peak SPL)	The peak-to-peak sound pressure level is the logarithmic ratio of the difference between the maximum and minimum pressure over the impulsive signal event to the reference pressure
Sound Exposure Level (SEL)	SEL is a measure of energy. Specifically, it is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1-s period
Power Spectral Density (PSD)	PSD describes how the power of a signal is distributed with frequency
Source Level (SL)	The acoustic source level is the level referenced to a distance of 1m from a point source
1/3 Octave Band Levels	The energy of a sound split into a series of adjacent frequency bands, each being 1/3 of an octave wide
Sound Speed Profile	A graph of the speed of sound in the water column as a function of depth

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APPENDIX B

PAM Specifications

Specifications of the PAM equipment

Hardware

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

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

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

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

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

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

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

Software

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

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

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

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

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

Species Detection

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

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

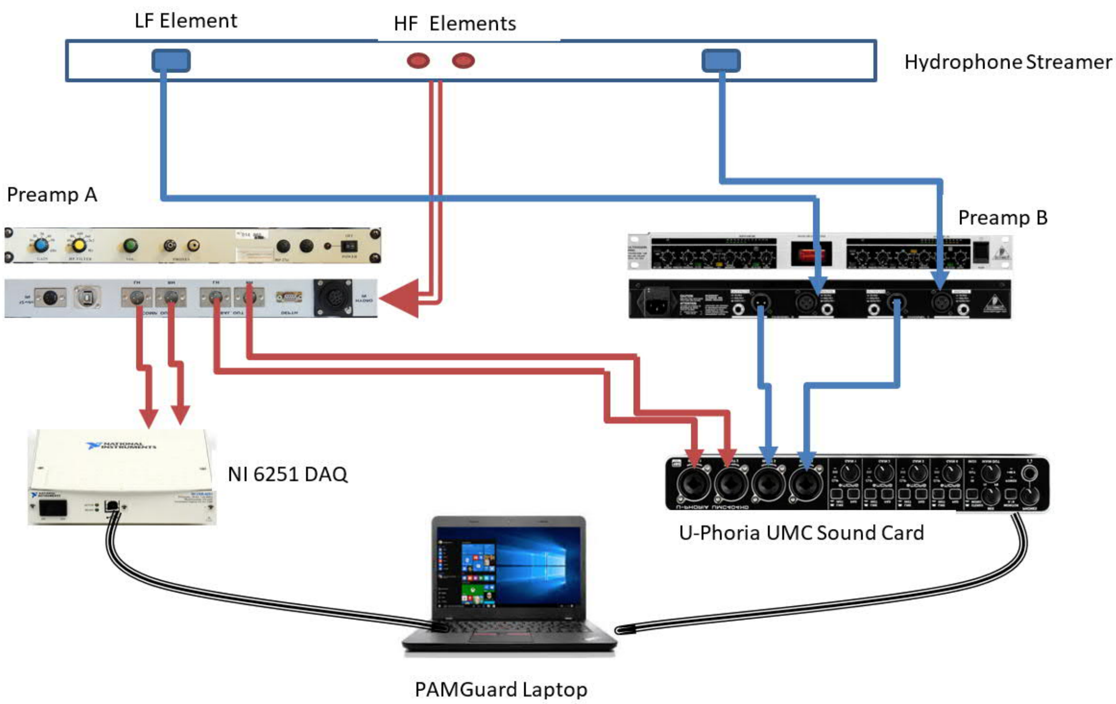

Figure 1 Schematic diagram showing the main elements of a typical six channel configuration of a Vanishing Point mitigation system.

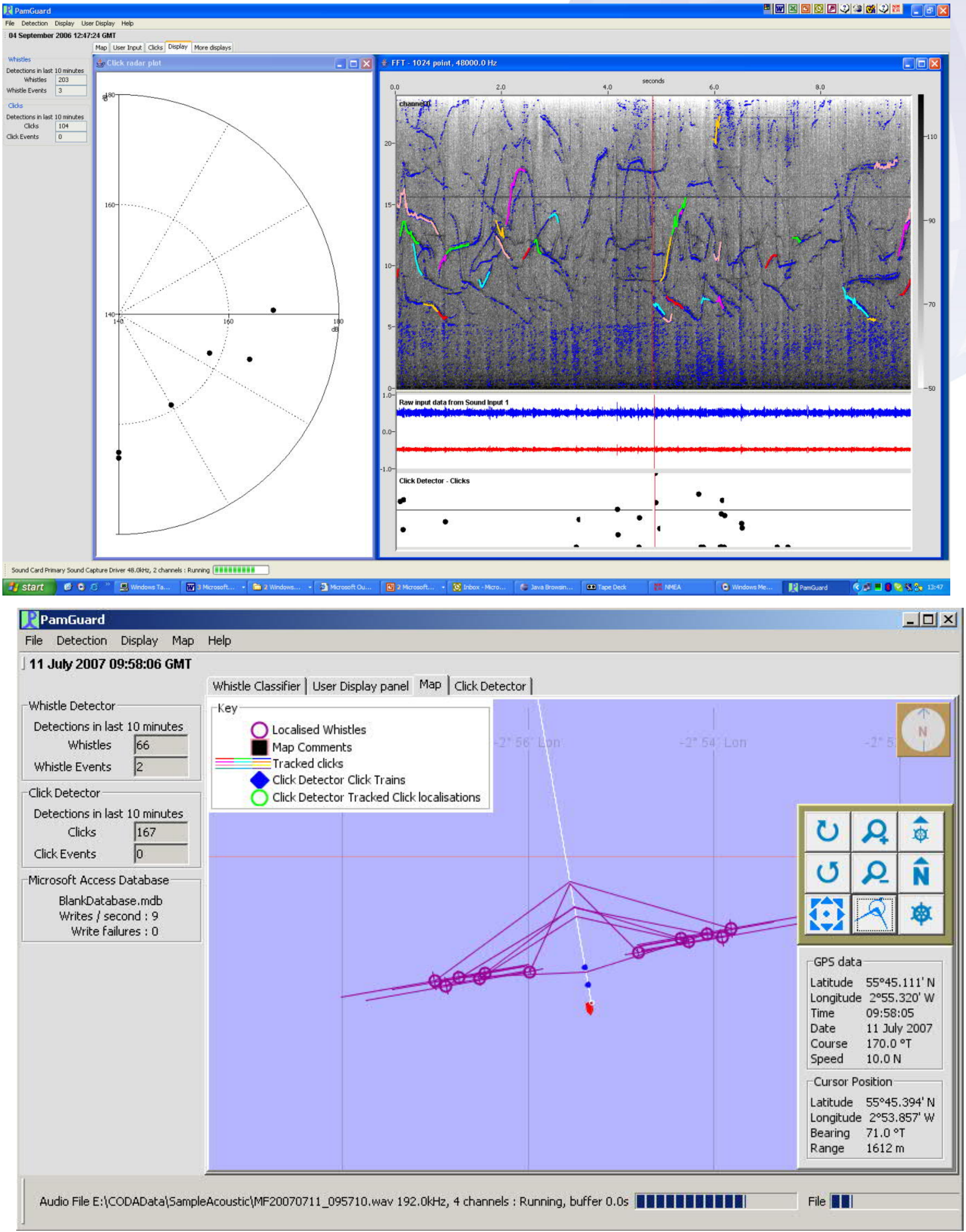

Figure 2 Screen shot from PAMGUARD Whistle and Click Detection and Mapping and Localisation Modules typical of a Seismic Mitigation configuration

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

General	PAMGUARD with appropriate configurations

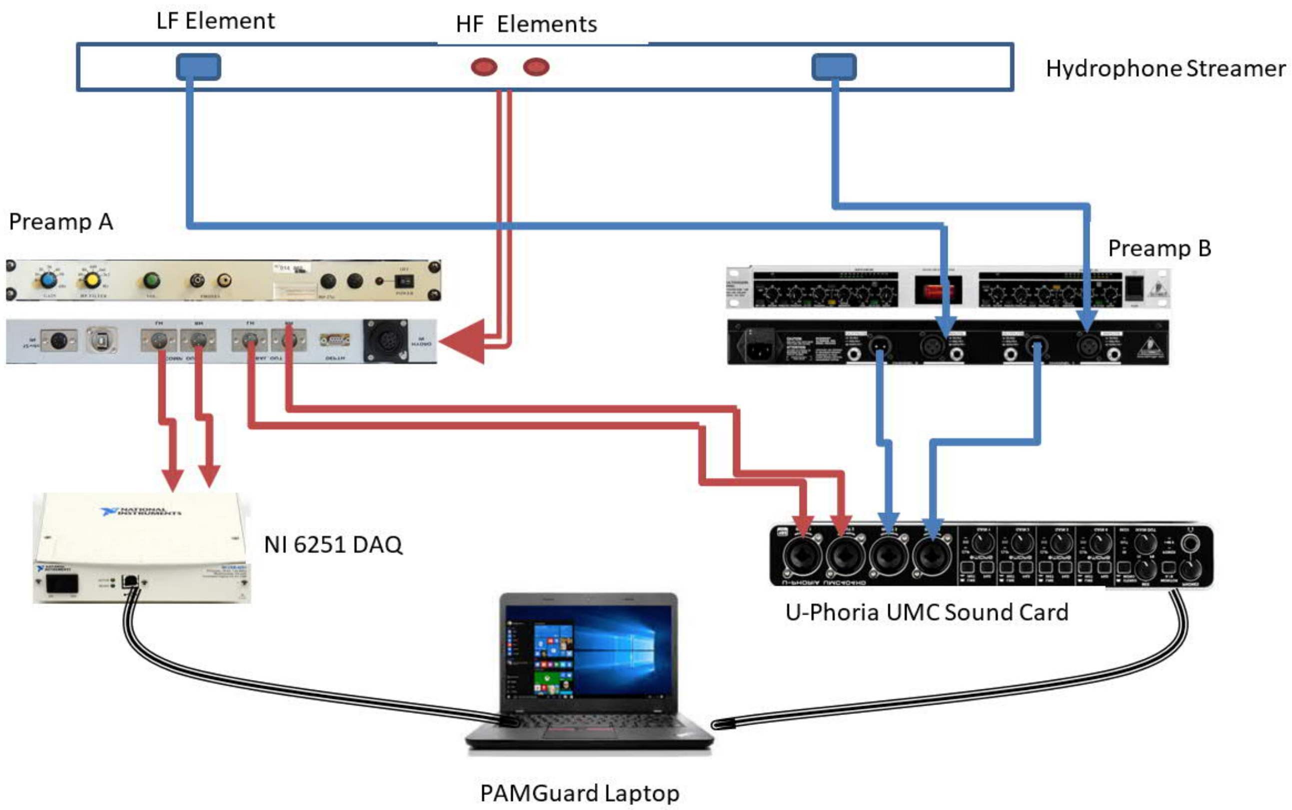

Figure 3 Schematic representation of BPM Multi-Channel PAM system

APPENDIX C

DOC Code of Conduct Species of Concern

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

APPENDIX D

Marine Mammal Mitigation Plan

MARINE MAMMAL MITIGATION PLAN

Taranaki and Māui EAD Checkshot Surveys

Prepared for:

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BASIS OF REPORT

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

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

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

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
740.10078-R01-v2.0	5 December 2019	SLR Consulting NZ Limited	[redacted]	[redacted]
740.10078-R01-v1.0	29 October 2019	SLR Consulting NZ Limited	[redacted]	[redacted]

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ABBREVIATIONS AND DEFINITIONS

Code of Conduct	Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations
DOC	Department of Conservation
EAD	Exploration and Appraisal Drilling
EPA	Environmental Protection Authority
MMIA	Marine Mammal Impact Assessment
MMMP	Marine Mammal Mitigation Plan
MMO	Marine Mammal Observer
MODU	Mobile Offshore Drilling Unit
OMV New Zealand	OMV New Zealand Limited
OTL	OMV Taranaki Limited
PAM	Passive Acoustic Monitoring

1 Introduction

1.1 Purpose of the Marine Mammal Mitigation Plan

The purpose of this Marine Mammal Mitigation Plan (**MMMP**) is to outline the procedures to be implemented for the responsible operation of seismic activities around marine mammals during checkshot surveying undertaken as part of the Taranaki Exploration and Appraisal Drilling (**EAD**) Programme and the Māui EAD Programme.

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

1.2 Survey Outline

OMV New Zealand Limited and OMV Taranaki Limited (collectively referred to as **OMV**) will be undertaking two EAD Programmes within the Taranaki Basin from 2019: the Taranaki EAD Programme and Māui EAD Programme. The purpose of these EAD Programmes is to determine the presence of hydrocarbons within a number of identified geological structures and to investigate the potential for future development of discovered hydrocarbons within the permit areas that OMV operates. The drilling of three wells is proposed: Gladstone-1, Toutouwai-1, and Māui-8. The water depths at the proposed well locations are 135 m, 131 m, and 110 m respectively. At each well location a checkshot survey may be undertaken (**Taranaki Checkshot Surveys**). Checkshot surveys are likely in wells where a hydrocarbon accumulation is discovered; they are unlikely to be required for 'dry' wells.

Three Operational Areas, within which all seismic operations will be restricted, are illustrated in **Figure 1**, and the coordinates for the corners of the Operational Areas are provided in **Table 1**.

Table 1 Operational Area Coordinates

Well	Easting (m)	Northing (m)	Latitude	Longitude
(Target depth)	NZTM-East	NZTM-North	WGS84 Decimal Degrees	
Gladstone-1 (3,079 m)	5708890	1645640	-38.76752	173.52535
	5707180	1652160	-38.78257	173.60053
	5703650	1651230	-38.81444	173.59009
	5705360	1644720	-38.79938	173.51499
Toutouwai-1 (4,361 m)	5671060	1611770	-39.10953	173.13614
	5670940	1614470	-39.11057	173.16737
	5663950	1613910	-39.17357	173.16103
	5664130	1611310	-39.17198	173.13093
Māui-8 (3,410 m)	5618490	1634010	-39.58263	173.39603
	5617390	1640080	-39.59228	173.46678
	5612330	1640340	-39.63786	173.47011
	5613020	1633120	-39.63195	173.38594

The Operational Areas do not enter the 12 NM territorial sea, and do not approach or enter the West Coast North Island Marine Mammal Sanctuary. Water depths within the Operational Areas are as follows:

- Gladstone-1: 132 – 140 m;
- Toutouwai-1: 130 – 131 m; and
- Māui-8: 110 – 111 m.

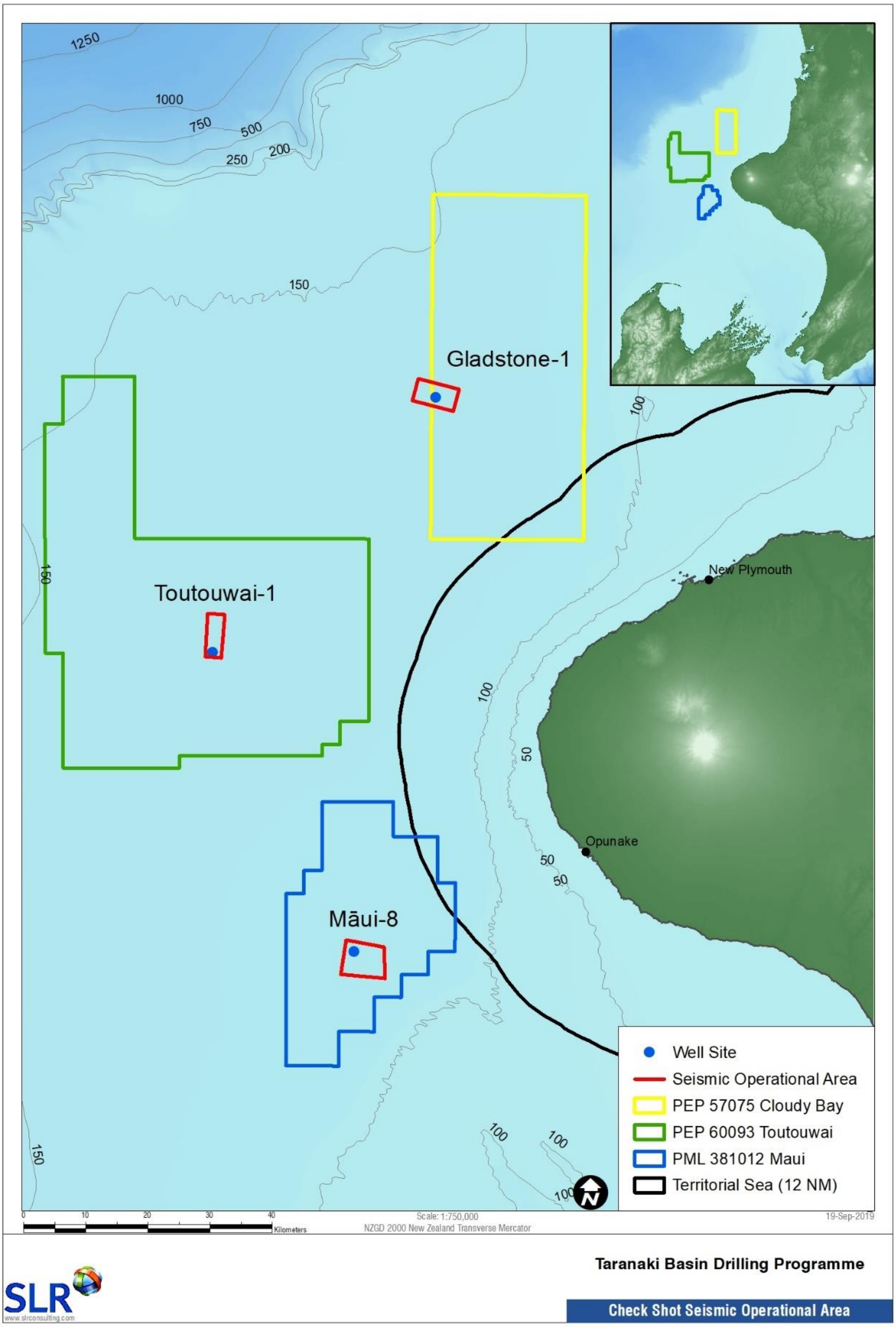
During checkshot surveys the acoustic source is lowered into the water column from a crane on the Mobile Offshore Drilling Unit (**MODU**). A downhole receiver is lowered into the recently completed wellbore to receive the sound. The acoustic source emits the first signal with the receiver at the deepest point in the well, after which the receiver is raised at pre-determined distance intervals within the wellbore and the process is repeated. This process continues until the receiver reaches a point within the subsurface where the signal received is too weak to be recorded accurately (typically due to the acoustic signal having to penetrate through multiple casing strings to reach the receiver inside the wellbore). Each full survey could take between 3.8 and 9.3 hours to complete, depending on the particular well characteristics and required information.

The acoustic source proposed for the three potential surveys is comprised of three 150 in^3 sub-sources, with an effective volume of 450 in^3. According to the Code of Conduct, the proposed checkshot surveys are classified as Level 1 seismic surveys on account of the acoustic source being greater than 427 in^3.

During the checkshot surveys a support vessel will be present close to the MODU (circling at approximately 1 km). The Marine Mammal Observers (**MMO**) will be onboard the MODU; however, due to the interfering noise source that is emitted from the MODU, the Passive Acoustic Monitoring (**PAM**) system and PAM Operators will be stationed onboard the support vessel.

As the drilling schedule for each well is currently unknown it is not possible to provide a detailed timeframe for when the checkshot surveys might occur. Additionally, as each EAD Programme could be completed over multiple years, there is no certainty as to the time of year that any particular checkshot survey may occur. Unlike traditional 2D or 3D seismic surveys, checkshot surveys are not constrained by weather conditions or season, unless weather conditions are so severe that the MODU cranes cannot be operated.

Figure 1 Location of Operational Areas



2 Procedures for Seismic Operations

2.1 Standard Procedures

The procedures outlined below are stipulated by the Code of Conduct and represent the standard mitigations that operators implement for compliance with the Code of Conduct during a Level 1 seismic survey. **Section 2.2** describes the variations that are specific to the Taranaki Checkshot Surveys.

2.1.1 Notification

The notification requirements of the Code of Conduct have been adhered to. A letter was received by the Director-General of Conservation at DOC on 26 June 2019 notifying OMV's intentions to carry out the Taranaki Checkshot Surveys.

2.1.2 Marine Mammal Impact Assessment

Under normal circumstances, a Marine Mammal Impact Assessment (**MMIA**) must be submitted to the Director-General of Conservation not less than one month prior to the start of a checkshot survey. To fulfil this requirement, the MMIA for the Taranaki Checkshot Surveys was submitted to DOC in November 2019. This MMMP forms part of the MMIA. Note that the term 'Species of Concern' is used both in the MMIA and the Code of Conduct. **Appendix 1** lists these species.

2.1.3 Observer Requirements

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

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

- There will be at least two qualified MMOs on-board at all times;
- There will be at least two qualified PAM Operators on-board at all times;
- The roles of MMOs and PAM Operators are strictly limited to the detection and collection of marine mammal sighting data, and the instruction of crew on the Code of Conduct and the crew's requirements when a marine mammal is detected within mitigation zones (including pre-start, soft start and operating at full acquisition capacity requirements). A summary of MMO and PAM Operator duties are presented in **Table 2**;
- 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.

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

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

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

Table 2 Operational Duties of Qualified Observers

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.

2.1.4 PAM Operations

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

If the PAM system malfunctions[1] or becomes damaged, seismic operations may continue for 20 minutes without PAM while the PAM Operator diagnoses the problem. If it is found that the PAM system needs to be repaired, seismic operations may continue for an additional two hours without PAM as long as the following conditions are met:

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

2.1.5 Reporting Requirements

Qualified observers are required under the Code of Conduct to record and report all marine mammal sightings during the survey (regardless of where they occur in relation to a mitigation zone). The following standardised excel datasheets must be used:

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

All raw datasheets must be submitted directly to DOC at the earliest opportunity, but no longer than 14 days after the completion of each deployment. A written final report must also be provided to DOC at the earliest opportunity, but no later than 60 days after the completion of the survey.

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

Incidents of non-compliance with the Code of Conduct must be reported immediately to DOC and the Environmental Protection Authority (**EPA**). OMV will ensure that within 48 hours of the initial notification of non-compliance a short summary of the incident should be sent by email to DOC and the EPA to provide a written record that outlines the nature of the non-compliance, where it occurred, when it occurred, why it occurred, how it occurred and any steps that have been taken to prevent reoccurrence. OMV commits to comply with any requirements from the EPA in the event of a non-compliance event.

[1] PAM malfunction can relate to the towed PAM equipment, or the software used to receive, process and display acoustic detections.
[2] As observations cannot continue at night, seismic operations will not occur at night in the event that the PAM system malfunctions.

2.1.6 Pre-Start Observations

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

- The acoustic source cannot be activated during daylight hours unless:
  - At least one qualified MMO has made continuous visual observations around the source for the presence of marine mammals, using both binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes; and
  - Passive acoustic monitoring for the presence of marine mammals has been carried out by a qualified PAM Operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the relevant 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.

As the commencement of each checkshot survey at the three well locations meets the requirement of a 'new location', the following additional requirements for start-up at night or in poor sightings conditions will be applied:

- MMOs will 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.

2.1.7 Soft Starts

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

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

Where possible, initial activation of the acoustic source must be by soft start, unless the source is being reactivated after a break in firing less than 10 minutes before that time (not in response to a marine mammal observation within a mitigation zone). In the case of checkshot seismic surveying, activation of the acoustic source at least once within sequential 10 minute periods shall be regarded as continuous operation.

2.1.8 Mitigation Zones for Delayed Starts and Shutdowns

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

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

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

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

Species of Concern within a mitigation zone of 1 km

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

- A qualified observer confirms the Species of Concern has moved to a point that is more than 1 km from the source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a Species of Concern within 1 km of the source, and the mitigation zone remains clear.

Other Marine Mammals within a mitigation zone of 200 m

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

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

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

2.1.9 Acoustic Source Testing

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

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

2.1.10 Key Contacts and Communication Protocols

The key contact for DOC is Dave Lundquist who can be contacted by phone on [redacted] or email at [redacted]@doc.govt.nz. Dave is the point of contact for all DOC enquiries or notifications.

Any correspondence with the EPA should be directed to seismic.compliance@epa.govt.nz.

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

2.2 Additions to the Code of Conduct

The procedures outlined in this section are further to those required by the Code of Conduct. These additional procedures have been adopted by OMV for the purpose of the Taranaki Checkshot Surveys and have been agreed with DOC as part of the MMIA process. Based on this it is imperative that these procedures are considered as strict requirements of each survey and therefore constitute additional responsibilities of qualified observers during the Taranaki Checkshot Surveys.

2.2.1 Reporting Requirements

In addition to the reporting requirements outlined in **Section 2.1.5**, the following additional reporting components are required:

- Marine mammal sightings will be collected whilst in transit to the Operational Area. These records will be collated onto the DOC standardised 'Off-survey Excel Reporting Forms' (http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/seismic-surveys-code-of-conduct/off-survey-seismic-mmo-reporting-form.xls) and will be provided to DOC no later than 14 days after the completion of each deployment;
- MMOs will be vigilant for dead marine mammals observed at sea and will report details of these incidences to DOC in the final trip report; and
- MMOs to notify DOC immediately of any Hector's/Maui's dolphin sightings. These sightings will be made via telephone to [redacted] on [redacted], with a follow up email sent to [redacted]@doc.govt.nz.

2.2.2 Other

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

APPENDIX 1

Species of Concern

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

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