ENVIRONMENTAL OFFSHORE SERVICES LIMITED

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# Woodside Energy (New Zealand 55794) Limited

# Toroa 3D Marine Seismic Survey

# Marine Mammal Impact Assessment

Report 720.10001.00002-R0

18 December 2014

Version: Final

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| **Date** | 18 December 2014 |
| **Project no** | 740.10001.00002 |
| **Report status** | FINAL |

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| | |
|---|---|
| AEI | Areas of Ecological Importance |
| AIS | Automatic Identification System |
| ALARP | As Low as Reasonably Practicable |
| ASCV | Area of Significant Conservation Value |
| ASNZS | Joint Australian & NZ International Standard |
| CI | Confidence Interval |
| CMA | Coastal Marine Area |
| Code of Conduct | 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations |
| COLREGS | International Regulations for the Prevention of Collisions at Sea 1972 |
| dB | Decibels |
| DIR | Department of Industry and Resources |
| DOC | Department of Conservation |
| EEZ | Exclusive Economic Zone |
| EEZ Act | Exclusive Economic Zone and Continental Shelf Act 2012 |
| EMP | Environmental Management Plan |
| EOS | Environmental Offshore Services Limited |
| EPA | Environmental Protection Authority |
| ERA | Environmental Risk Assessment |
| FMA | Fisheries Management Area |
| GIS | Geographic Information System |
| GNS | GNS Science (NZ Crown Research Institute) |
| GPS | Global Positioning System |
| GSB | Great South Basin |
| HSE | Health and Safety in Employment |
| IAPPC | International Air Pollution Prevention Certificate |
| IMS | Invasive Marine Species |
| IOPPC | International Oil Pollution Prevention Certificate |
| ISO | International Management Standard |
| ISPPC | International Sewage Pollution Prevention Certificate |
| IUCN | International Union of Conservation of Nature |
| Km | Kilometre |
| MARPOL | International Convention for the Prevention of Pollution from Ships |
| MBIE | Ministry of Business, Innovation and Employment |
| MfE | Ministry for the Environment |
| MMIA | Marine Mammal Impact Assessment |

| | |
|---|---|
| MMMP | Marine Mammal Mitigation Plan |
| MMO | Marine Mammal Observer |
| MMS | Marine Mammal Sanctuary |
| MPI | Ministry for Primary Industry |
| MSL | MetOcean Solutions Ltd |
| MSS | Marine Seismic Survey |
| NABIS | National Aquatic Biodiversity Information System |
| NZMEC | New Zealand Marine Environment Classification |
| NIWA | National Institute of Water and Atmospheric Research |
| Nm | Nautical Mile |
| NZ | New Zealand |
| NZP&M | New Zealand Petroleum & Minerals |
| OMV | OMV NZ Ltd |
| PAM | Passive Acoustic Monitoring |
| PEP | Petroleum Exploration Permit |
| PEPANZ | Petroleum Exploration & Production Association New Zealand |
| PNA | Protected Natural Area |
| QMS | Quota Management System |
| ROMS | Regional Oceans Modelling System |
| SEL | Sound Exposure Level |
| SNR | Source to Noise Ratio |
| SOPEP | Shipboard Oil Pollution Emergency Plan |
| SRD | Self-Recovery Devices |
| SST | Sea Surface Temperature |
| STLM | Sound Transmission Loss Modelling |
| VHF | Very High Frequency |
| UK | United Kingdom |
| USA | United States of America |
| WEL | Woodside Energy (New Zealand 55794) Limited |

# 1 Introduction

## 1.1 Background

Woodside Energy (New Zealand 55794) Limited (WEL), are proposing to acquire a 3D Marine Seismic Survey (MSS) of approximately 1,140 km$^2$ in the Great South Basin. The Toroa Survey Area will be located over Petroleum Exploration Permit (PEP) 55794 and will be bound by an Operational Area; allowing for operation of line turns, acoustic source testing and soft start initiation (Figure 1). A well tie will take place from the Toroa Survey Area consisting of one swath of seismic acquisition to the previously drilled Pakaha-1 well to tie in the down hole stratigraphy data from the Pakaha-1 well to the Toroa 3D MSS. It is anticipated that WEL's Toroa 3D MSS will take approximately 35 days to acquire, depending on weather constraints and marine mammal encounters. The seismic vessel *Polar Duke* has been contracted to undertake the Toroa 3D MSS with an anticipated commencement date of late February 2015.

Under Section 23 of the Crown Minerals Act 1991, the purpose of a PEP is to identify petroleum deposits and evaluate the feasibility of mining any discoveries that are made, and is exclusive to the permit holder. PEP 55794 allows WEL to undertake geological or geophysical surveying, exploration and appraisal drilling and testing of petroleum discoveries. Further details in regards to the Crown Minerals Act is provided in Section 2.1.

The Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects – Permitted Activities) Act (EEZ Act) was promulgated and came into effect on 28 June 2013. The EEZ Act manages the previously unregulated potential for adverse environmental effects of activities in the EEZ and continental shelf. Under the EEZ Act, a MSS is classified as a permitted activity, providing the operator undertaking the MSS complies with the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations' (Code of Conduct) (DOC, 2013a). The Code of Conduct is further explained in Section 2.3.

Environmental Offshore Services Ltd has been contracted to prepare the Toroa 3D Marine Mammal Impact Assessment (MMIA) in accordance with the Code of Conduct (Appendix 1: Marine Mammal Impact Assessment) to assess the potential environmental effects from the Toroa 3D MSS, the sensitive environments and marine species in the surrounding areas and mitigation measures to avoid or minimise any potential effects.

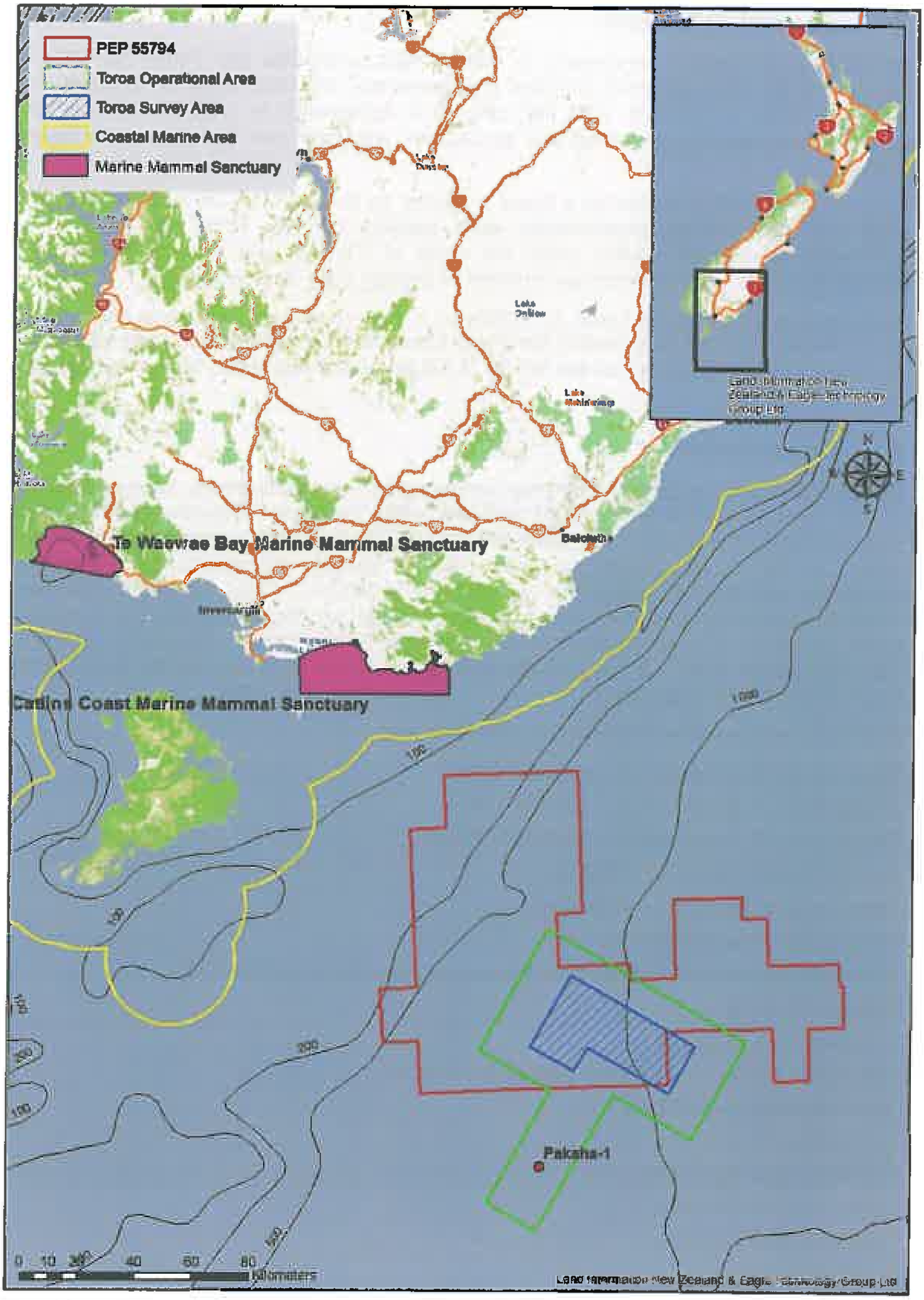


**Figure 1: Location Map of Toroa Survey Area, Operational Area and Pakaha-1 well tie**

## 1.2 General Approach

The MMIA is an integral component to ensure WEL undertake the Toroa 3D MSS in adherence to the EEZ permitted activities regulations and the DOC Code of Conduct. As well as the Code of Conduct, WEL will operate in accordance to relevant NZ laws and regulations, international guidelines and procedures and their own internal environmental standards.

The Toroa 3D MSS is classified as a 'Level 1 Survey' by the Code of Conduct and WEL will comply with the relevant requirements while carrying out the Toroa 3D MSS. The requirements of a Level 1 MSS within the Code of Conduct and associated mitigation measures that WEL will implement are outlined in Section 2.3.1 and Section 5.3.1.

During the preparation of the Toroa 3D MMIA, an extensive review of literature and existing data on the environment surrounding the Toroa Operational Area has been undertaken and is summarised within Section 4 of this MMIA. A full list of references can be found in Section 8.

## 1.3 Consultation

WEL has undertaken consultation with key interested parties, stakeholders, hapū and iwi that were identified in relation to the MSS activities within the Toroa Operational Area. The groups involved in the engagement process were defined through the geographic extent and location of the Toroa Operational Area, WEL's internal procedures for community engagement and through discussions with DOC and NZPAM. This consultation process involved groups being consulted either in person, through an information sheet or contacted over the phone or via email to describe the proposed Toroa 3D MSS operations within the Toroa Operational Area. A copy of the information sheet sent out for the consultation process is attached in Appendix 1.

The groups that were consulted with are defined below:

- Department of Conservation – National Office;
- Department of Conservation – Dunedin Office;
- Department of Conservation – Southland Office;
- Environmental Protection Authority;
- New Zealand Petroleum & Minerals;
- Ministry for Primary Industries;
- Petroleum Exploration & Production Associated New Zealand (PEPANZ);
- Otago University;
- Invercargill City Council;
- Venture Southland – Southland Energy Consortium;
- Environment Southland;
- Te Ao Marama Inc;
- Te Runanga o Ngai Tahu;
- Oraka-Aparima Runaka;
- Te Runanga o Waihopai;
- Awarua Runanga;
- Te Runanga o Hokonui;
- Deepwater Group;
- Sealord;
- Maruha NZ Ltd;

- Independent Fisheries;
- Talley's Group;
- Sanford Limited;
- Southern Inshore Fisheries Management Company Limited;
- NZ Federation of Commercial Fishermen;
- Anton's Seafoods; and
- Moana Seafoods.

A consultation register of WEL's engagements is included in Appendix 2.

## 1.4 Research

Throughout the world where MSSs are undertaken, research is being conducted to assess any potential effects from MSS operations on marine species and habitats. The Code of Conduct states that research opportunities relevant to the local species, habitats and conditions should be undertaken, while being aware of not duplicating international efforts (DOC, 2013).

Under the Code of Conduct, within 60 days following the completion of the Toroa 3D MSS, a Marine Mammal Observer (MMO) report is to be submitted to DOC. This report is to include all the marine mammal observational data, where shut downs occurred due to marine mammals within the mitigation zones and GPS coordinates of each marine mammal sighting. This information will contribute to the DOC marine mammal sighting database and can be used for research purposes by DOC, Universities or other institutions to further understand distribution of marine mammals and their behaviour around a seismic vessel. The dedicated trained and experienced MMOs on the *Polar Duke* will increase DOC's knowledge of marine mammals in the area as presently there is very little information

New Zealand is a hotspot for marine mammal strandings. Since 1840, more than 5000 strandings of whales and dolphins have been recorded around the New Zealand coast. During any stranding event, DOC will be responsible for all aspects of undertaking a necropsy and coordination with pathologists at Massey University; the performance of a necropsy will assess whether the cause of death was from any auditory pressure related injuries. If a marine mammal is found inshore of the Toroa 3D MSS operational area and within two weeks of the end of the survey, and cannot be attributed to shark attacks or vessel collision, WEL will consider covering the costs directly associated with Massey University undertaking a necropsy.

# 2 Legislative Framework

The NZ Government's oil, gas, mineral and coal resources are administered by New Zealand Petroleum & Minerals (NZP&M) and are often regarded as the Crown Mineral Estate. NZP&M's role is to maximise the gains to NZ from the development of mineral resources, in line with the Government's objectives for energy and economic growth. NZP&M is a branch of the Ministry of Business, Innovation and Employment (MBIE) and they report to the Minister of Energy and Resources.

There is a wide range of legislation applicable to the offshore petroleum industry which regulates maritime activities, environmental protection, biosecurity and industrial safety. For the Toroa 3D MSS, WEL are required to comply with the Crown Minerals Act 1991, EEZ Act – Permitted Activities and the Code of Conduct.

## 2.1 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, offshore in the EEZ and extended continental shelf. This Act was amended on 24 May 2013.

The Crown Minerals Act regime comprises the Crown Minerals Act 1991, two minerals programmes (one for petroleum and one for other Crown-owned minerals), and associated regulations. Together, these regulate the exploration and production of Crown-owned minerals (NZP&M, 2014a).

The petroleum minerals programme 2013 took effect on 24 May 2013 and now applies to all applications for permits for petroleum activities. It sets out the policies and procedures to be followed for the allocation of mineral resources, while the requirements to be met by permit holders are defined in the regulations. The programme also defines specific requirements for consultation with iwi and hapū, including the matters that must be consulted on (such as all permit applications) and the consultation principles.

## 2.2 Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act

The purpose of the EEZ Act is to promote the sustainable management of natural resources within the EEZ and Continental Shelf. Sustainable management involves managing the use, development and protection of natural resources in a way, and at a rate, that enables people to provide for their economic well-being while:

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

The Minister for the Environment can classify activities within the EEZ and Continental Shelf as:

- **Permitted** – the activity can be undertaken provided the operator meets the conditions specified within the regulations. Marine seismic surveys are a permitted activity as long as the operator complies with the DOC Code of Conduct. This Code of Conduct was developed as part of DOC's mandate to administer and manage marine mammals under the Marine Mammal Protection Act (1978). Therefore the Director-General of DOC must assess a MMIA as compliant with the provisions of the Code of Conduct before any MSS can commence. Seismic survey operators do not have to comply with the prior notification requirements in Schedule 1 of the Permitted Activity Regulations, or supply reports of the activity to the EPA. If an operator chooses not to implement the Code of Conduct during the planning stage of a MSS, then the activity becomes a discretionary activity under the EEZ Act;
- **Non-notified discretionary** – the activity can be undertaken if applicants obtain a marine consent from the Environmental Protection Authority (EPA), who may grant or decline consent and place conditions on the consent. The consent application is not publically notified and has statutory timeframes adding up to 60 working days in which the EPA must assess the marine consent application;
- **Discretionary** – the activity can be undertaken if applicants obtain a marine consent from the EPA. The consent application will be publicly notified; submissions will be invited; and hearings will be held if requested by any party, including submitters. The process has a statutory timeframe of 140 working days during which the EPA must assess the marine consent application; and

- **Prohibited** – the activity may not be undertaken.

The classification for each activity depends on a number of considerations outlined in Section 33 of the EEZ Act. These considerations include; the environmental effects of the activity, the importance of protecting rare and vulnerable ecosystems, and the economic benefit to NZ of an activity taking place.

The EPA will monitor for compliance with the permitted activity regulations for seismic surveys, which relates to the Code of Conduct, and may conduct audits. The EPA is the enforcement agency for compliance with the EEZ Act and has the authority to take enforcement action if any activities undertaken by an operator are non-compliant within the EEZ.

## 2.3 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations

The 2013 Code of Conduct was developed by DOC in consultation with a broad range of stakeholders involved with marine seismic survey operations in NZ. It replaced the 2012 Code of Conduct on 29 November 2013. Schedule 2 of the Code of Conduct classifies all NZ cetacean species except common dolphins, dusky dolphins and NZ fur seals as species of concern (DOC, 2013a).

The 2012 Code of Conduct was initially developed as a voluntary regime to be adopted by the petroleum industry while conducting MSS operations in NZ waters. The aim of the code was to manage the potential effects of MSS activities while teething issues around the application of this legislation were ironed out. It was believed that the initial 2012 Code of Conduct achieved world-leading environment protection, while providing for the sustainable economic development that is vital to NZ's future prosperity. When the EEZ Act came into effect, on 28 June 2013, seismic surveys became classified as "permitted activities" (Section 2.2) and operators undertaking MSSs in the EEZ or Continental Shelf were required to comply with the Code of Conduct. This resulted in the 2012 Code of Conduct being reviewed in order to take account of the operational difficulties which had been identified and make the Code of Conduct enforceable from a regulatory perspective.

Amendments included in the 2013 Code of Conduct comprised a reduced period of time that a NZ fur seal has to be beyond the 200 m mitigation zone before the pre-start observations can commence; operational procedures to implement if the PAM system malfunctions; and a slight change to pre-start observations. The full mitigation requirements within the updated 2013 Code of Conduct are provided in Section 2.3.1.

### 2.3.1 General requirements

#### *2.3.1.1 Notification*

Any operator undertaking a MSS (except those classified as Level 3 (see Section 2.3.2)) has to provide notification to the Director-General of DOC at the earliest opportunity but not less than three months prior to commencement. Notification was provided to the Director-General on 9th September 2014 in regards to the Toroa 3D MSS within PEP 55794.

#### *2.3.1.2 Marine Mammal Impact Assessment*

The Code of Conduct requires a MMIA to be developed and submitted to the Director-General not less than one month prior to the start of MSS acquisition in order to ensure that all potential environmental effects and sensitivities have been identified and measures to reduce potential environmental effects are in place.

#### *2.3.1.3 Areas of Ecological Importance*

MSS operations within an Area of Ecological Importance (AEI) require more comprehensive planning and consideration, including additional mitigation measures to be developed and implemented through the MMIA process.

The locations and extent of the AEI in NZ continental waters were determined from DOC's database of marine mammal sightings and strandings, fisheries-related data maintained by Ministry for Primary Industries (MPI) and the National Aquatic Biodiversity Information System (NABIS). Where data was incomplete or absent, technical experts have helped refine the AEI maps.

Within the Code of Conduct it states that, under normal circumstances, a MSS will not be planned in any sensitive ecologically important areas; during key biological periods where Species of Concern are likely to be feeding or migrating, calving, resting, feeding or migrating; or where risks are particularly evident such as in confined waters.

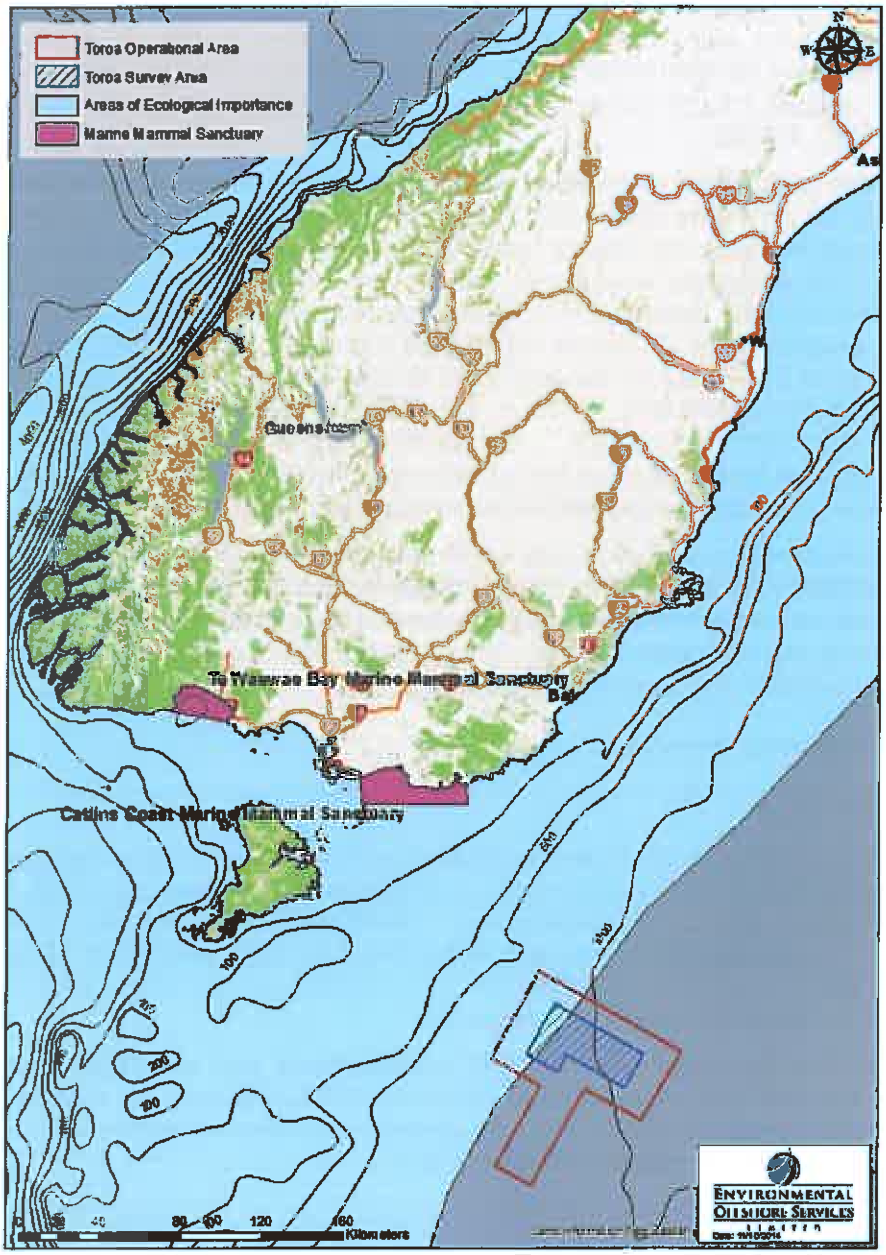


**Figure 2: Toroa Operational Area, Areas of Ecological Importance and Marine Mammal Sanctuaries**

As detailed in Schedule 1 of the Code of Conduct, when it is necessary and unavoidable to conduct a MSS in an AEI, additional mitigation measures are to be put in place. The Toroa Operational Area straddles the offshore boundary of an AEI (Figure 2) and the additional measures that WEL will implement, following discussions with DOC, are identified in Section 5.3.2.

When an MSS is undertaken within an AEI, the Code of Conduct also requires Sound Transmission Loss Modelling (STLM) to be undertaken to validate the specified mitigation zones. The STLM is based on the specific configuration of the acoustic array deployed from the *Polar Duke* and the environmental conditions (i.e. bathymetry, substrate, water temperature and underlying geology) within the Toroa Operational Area (see Section 5.1.2.1). The Code of Conduct states that if Sound Exposure Levels (SELs) are predicted to exceed 171 dB re 1µPa$^2$.s (behaviour criteria) corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1µPa$^2$.s (injury criteria) at 200 m, consideration will be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly.

The STLM is discussed in more detail in Section 5.1.2.1.

#### *2.3.1.4 Marine Mammal Sanctuaries*

There are six gazetted Marine Mammal Sanctuaries (MMS) around NZ which were implemented to protect marine mammals from harmful human impacts, particularly in vulnerable areas such as breeding grounds, migratory routes or endangered species habitats. All MMS are administered and managed by DOC in accordance with the Marine Mammals Protection Act 1978, Marine Mammals Protection Regulations 1992 and in line with Conservation General Policy 2005.

A MMS does not exclude all fishing or seabed mining activities; however it can place restrictions on seismic surveys and/or mining to prevent and minimise disturbance of marine mammals the MMS were gazetted to protect. In order to conduct a seismic survey within a MMS, an operator must notify the Director-General of DOC (see Section 2.3.1.1), submit a written Environmental Impact Assessment (see Section 2.3.1.2), and must comply with any additional conditions such as an increase in mitigation zones or number of observers (see Section 5.3.2).

There are two MMSs in the vicinity of the Toroa Operational Area. The Catlins Coast MMS is located approximately 110 km to the northwest of the Toroa Survey Area and the Te Waewae Bay MMS is located approximately 215 km northwest of the Toroa Survey Area. A full description of these MMS can be found in Section 4.3.4.

### 2.3.2 Level 1 Marine Seismic Survey Requirements

The 2013 Code of Conduct distinguishes three classes of survey according to the size of the acoustic source used for data collection and sets out requirements for each class. The Toroa 3D MSS is classified as a Level 1 survey under the Code of Conduct (i.e. a survey using an acoustic source which has a total combined operational capacity that exceeds 427 cubic inches (in$^3$)). Most MSS for oil and gas exploration activities are classified as Level 1, which feature the most stringent requirements for marine mammal protection and is the main focus of the Code of Conduct.

The Level 1 MSS observer and operational requirements which WEL will follow are listed in the following sections.

#### *2.3.2.1 Observer Requirements*

In addition to visual MMOs on-board the survey vessel, passive acoustic monitoring (PAM) is also required as a mitigation measure under a Level 1 MSS. A Seiche 250 m Array PAM system will be utilised for the Toroa 3D MSS.

The ability to acoustically detect animals, including the maximum range at which they can be detected, is critically dependent on the levels of background noise. The Seiche PAM system comprises a 250 m array with integral hydrophones and a depth sensor array. The sensor array comprises of a 20 m detachable array section with four hydrophone elements (two broadband and two wideband). Two are set with a bandwidth of 10 Hz to 200 kHz, where it can be seen in Appendix 3 that the hydrophones start to roll off at 10 Hz, but remains sensitive down to 1 Hz where it will still register 4 dB. Whereas the second set of hydrophones is set to a bandwidth of 2 kHz to 200 kHz sensitivity. This ensures that if the lower frequency pair of hydrophones is saturated by vessel noise, the system will still be capable of detecting vocalising marine mammals (Appendix 3).

The DOC-endorsed senior PAM Operator that will be onboard the *Polar Duke* during the Toroa 3D MSS also confirmed that the PAM system planned to be used is suitable for detection of NZ endemic and vagrant marine mammal species. Technical details of the PAM system to be used in the Toroa 3D MSS are included in Appendix 3.

The Code of Conduct states that where additional mitigation measures are required a Marine Mammal Mitigation Plan (MMMP) is to be developed and circulated amongst the observers and crew to guide the offshore operations. The MMMP has been compiled by the MMO and PAM system provider Blue Planet Marine and is attached in Appendix 4.

To undertake the Toroa 3D MSS in compliance with the Code of Conduct, the minimum qualified observer requirements are:

- At all times there will be at least two qualified MMOs onboard;
- At all times there will be at least two qualified PAM operators onboard;
- The observers' role on the vessel during the Toroa 3D MSS is 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 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 observer must not exceed 12 hours per day.

DOC also encourage observations at all times where practical and possible to help build on the knowledge and distribution of marine mammals around the NZ coastline.

If during the Toroa 3D MSS the MMOs onboard the *Polar Duke* consider that there are higher numbers of marine mammals encountered than what is summarised in this MMIA, the Director-General will be notified immediately. A decision on what adaptive management procedures will be implemented if this scenario arises will depend on the marine mammal species observed and the situation which is occurring at that time. This management decision will result from discussions between DOC and WEL, who shall then advise the MMO/PAM team of the correct approach.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans, any such bioacoustics detections will require an immediate shutdown of an active survey or will delay the start of operations, regardless of signal strength or whether distance or bearing from the acoustic source has been determined. It is not necessary to determine whether the marine mammal is within a mitigation zone. 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'.

If the PAM system onboard the *Polar Duke* malfunctions or becomes damaged, MSS 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, MSS 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 MSS operations when PAM is not operational;
- DOC is notified via email as soon as practicable, stating time and location in which MSS operations began without an active PAM system; and
- MSS 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.

#### *2.3.2.2 Operational and Reporting Requirements*

Both visual MMOs and PAM operators are required to record and report all marine mammal sightings during MSSs conducted in adherence to the Code of Conduct. All raw datasheets must be submitted by the qualified observers directly to DOC at the earliest opportunity but no longer than 14 days after completion of each deployment. A written final trip report must also be submitted to DOC at the earliest opportunity but no longer than 60 days after completion of the Toroa 3D MSS.

**MMO requirements include:**

- Provide effective briefings to crew members, and establish clear lines of communication and procedures for onboard 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;
- Use GPS, sextant, reticle binoculars, compass, measuring sticks, angle boards or any other appropriate tools to accurately determine distances/bearings and plot positions of marine mammals whenever possible during sightings;
- Record and report all marine mammal sightings, including species, group size, behaviour/activity, presence of calves, distance and direction of travel (if discernible);
- Record sighting conditions (Beaufort sea state, swell height, visibility, fog/rain and glare) at the beginning and end of the observation period, and whenever the weather conditions change significantly;
- Record 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; and
- Record and report to DOC any instances of non-compliance with the Code of Conduct.

**PAM operator requirements include:**

- Provide effective briefings to crew member to establish clear lines of communication and procedures for onboard operations;
- Deploy, retrieve, test and optimise hydrophone arrays;
- 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;
- Use appropriate sample analysis and filtering techniques;

- 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 type and nature of sound, time and duration heard;
- Record general environmental conditions;
- Record 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; and
- Record and report to DOC any instances of non-compliance with the Code of Conduct.

#### *2.3.2.3 Pre-start Observations*

**Normal Requirements**

The Toroa 3D MSS acoustic source can only be activated if it is within the Toroa Operational Area (Figure 1) and no marine mammals have been observed or detected in the relevant mitigation zones (Section 2.3.2.4) and has followed the procedures listed below in this section.

During daylight hours the Toroa 3D MSS acoustic source cannot be activated unless:

- At least one qualified MMO has made continuous visual observations around the source for the presence of marine mammals, from the bridge (or preferably even higher vantage point) using both binoculars and the naked eye, and no marine mammals have been observed in the respective mitigation zones for at least 30 minutes; and
- Passive acoustic monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalising cetaceans have been detected in the respective mitigation zones.

During night-time hours or poor sighting conditions (daylight visibility of <1.5 km or a sea state greater than or equal to Beaufort 4), the acoustic source cannot be activated 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.

**Soft Starts**

The Toroa 3D MSS acoustic source will not be activated at any time except by soft start, unless the source is being reactivated after a single break in firing (not in response to a marine mammal observation within a mitigation zone) of less than 10 minutes immediately following normal operations at full power, and the qualified observers have not detected marine mammals in the relevant mitigation zones. No repetition of the less than 10 minute break period in the commencement of a soft start is allowed under the Code of Conduct.

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 capacity defined in this MMIA (3,460 $in^3$) is not to be exceeded during the soft start period.

**Additional requirements for start-up in a new location in poor sighting conditions**

In addition to the normal pre-start observation requirements above, when the *Polar Duke* arrives at the Toroa Operational Area for the first time, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless either:

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

This procedure will be followed each time the *Polar Duke* retruns to the Toroa Operational Area after a crew change or a port call.

#### *2.3.2.4 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 (which includes soft starts), a qualified observer detects at least one Species of Concern ((DOC, 2013a) – Schedule 2) 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.

**Species of Concern within a mitigation zone of 1.0 km**

If during pre-start observations or while the acoustic source is activated, a qualified observer detects a Species of Concern within 1.0 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 1.0 km from the source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of a Species of Concern within 1.0 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 Toroa 3D MSS 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.

# 3 Project Description

## 3.1 Marine Seismic Surveys

The basic principle behind a MSS is that an energy source (i.e. acoustic source), instantaneously releases compressed air, releasing a directionally focused acoustic wave at low frequency that travels several kilometres through the earth. As the acoustic wave travels through the earth, portions are reflected by the underlying rock layers and the reflected energy is recorded by receivers (hydrophones) deployed in streamers. Depths and spatial extent of the strata can be calculated and mapped, based on the difference between the time of the energy being generated and subsequently recorded by the receivers.

### 3.1.1 2D and 3D surveys

MSS fall into two main categories of varying complexity: 2D and 3D. A 2D MSS can be described as a fairly basic survey method which involves a single source and a single streamer towed behind the seismic vessel (Figure 3). In contrast, a 3D MSS is a more complex method which involves a greater investment and much more sophisticated equipment.

Although the 2D MSS is simplistic in its underlying assumptions, it has been and is still used today to great effect in discovering oil and gas reservoirs. The method's underlying assumption is that the reflections from the subsurface lie directly below the seismic vessel's sail line. Sail lines are generally acquired several kilometres apart, on a broad grid over a large area. 2D MSS are commonly used for frontier exploration areas in order to acquire a general understanding of the regional geological structure and to identify prospective survey areas to be comprehensively examined through a 3D MSS.

Whereas the purpose of a 3D MSS is to focus on a specific area over known geological targets considered likely to contain hydrocarbons, generally discovered from previous 2D MSSs. Extensive planning is undertaken to ensure the survey area is precisely defined and the direction of the survey lines are calculated to in order to obtain the best results. A sail line separation within the survey area for 3D surveys is normally 200 – 400 m, often with two acoustic sources and up to 10 streamers, typically 100 m apart, producing a three-dimensional image of the subsurface (Figure 3).

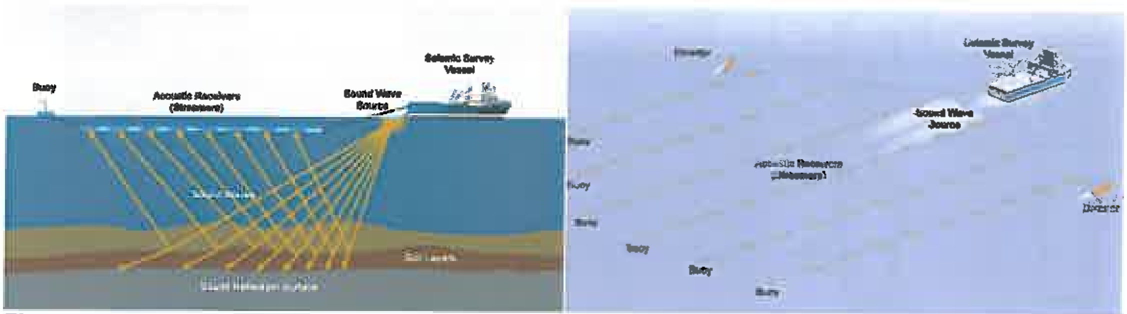


**Figure 3: Schematic of a 2D MSS (left) and 3D MSS (right)**
**Source:** www.fishsafe.eu

### 3.1.2 Equipment

#### *3.1.2.1 The acoustic source*

The acoustic source used during MSS is comprised of two high pressure chambers: an upper control chamber and a discharge chamber (Figure 4). High pressure air (~2,000 psi) from compressors onboard the seismic vessel is continuously fed to the acoustic sources towed behind the vessel via an air hose. This forces the piston downwards, and the chambers fill with high-pressure air while the piston remains in the closed position (Figure 4).

The acoustic source is activated by sending an electrical pulse to the solenoid valve which opens, and the piston is forced upwards, allowing the high pressure air in the lower chamber to discharge to the surrounding water through the airports. The air from these ports forms a bubble, which oscillates according to the operating pressure, the depth of operation, the temperature and the volume of air vented into the water. Following this release, the piston is forced back down to its original position by the high-pressure air in the control chamber, so that once the discharge chamber is fully charged with high-pressure air, the acoustic source can be released again. The compressors are capable of recharging the acoustic source rapidly and continuously which enables the acoustic source arrays to be fired every 10 – 11.5 seconds during seismic acquisition.

Acoustic source arrays are designed so that they direct most of the sound energy vertically downwards (Figure 4) although there is some residual energy which will dissipate horizontally into the water. The amplitude of sound waves generally declines with distance from the acoustic source, and the weakening of the signal with distance (attenuation), is frequency dependent, with stronger attenuation at higher frequencies. In practice, 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.

Typical source outputs used in MSS operations will emit ~220 – 250 dB when measured relative to a reference pressure of one micropascal (re 1µPa/m) (IAGC, 2002). However, this does depend on how many acoustic sources are fired together; generally they are activated alternatively. To place this in perspective, low level background noise in coastal regions with little wind and gentle wave action is ~ 60 dB re 1µPa/m, while in adverse weather conditions, the background noise increases to 90 dB re 1µPa/m (Bendell, 2011).

The sound frequencies emitted from the acoustic source are broad band. Most of the energy is concentrated in the 10 – 250 Hz range with lower levels in the 200 – 1,000 Hz range and the largest amplitudes are usually generated in the 20 – 100 Hz frequency band.

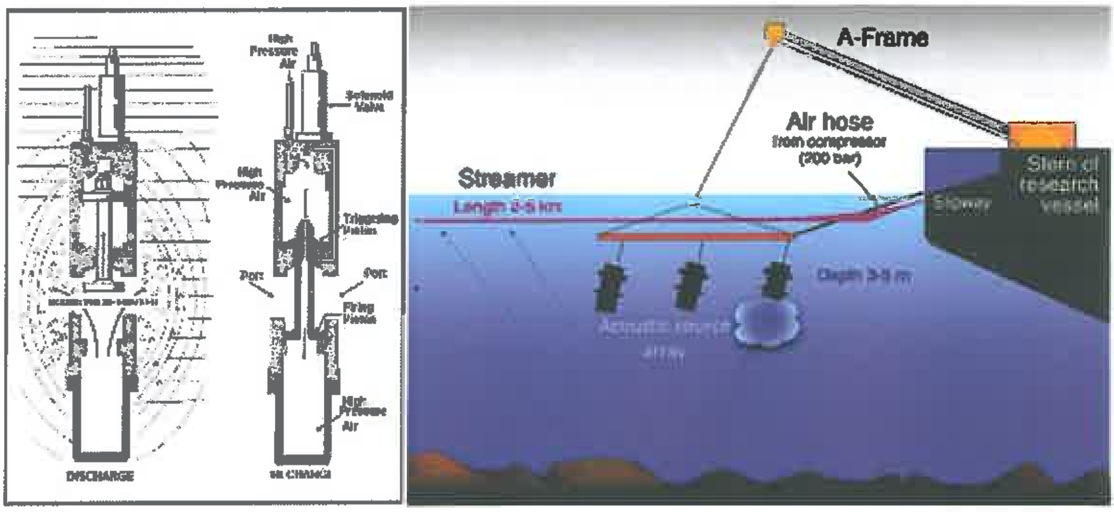


**Figure 4: Schematic cross section of a typical acoustic source and a sub-surface multi acoustic source array**

### *3.1.2.2 Sound in Water*

The decibel (dB) system is used to express the relative loudness (amplitude) of sound. The decibel system is logarithmic, which results in an exponential scale being represented as a linear scale. Decibel is not a measuring unit, but a ratio that must be expressed using a reference (benchmark) value.

Frequency is another measure of sound. It is the number of pressure waves that pass by a reference point per unit of time and is measured in Hertz (Hz), or cycles per second.

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

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

The ocean is a noisy environment generated from a variety of natural sources such as wind, waves, marine life, underwater volcanoes and earthquakes. There are also man-made (anthropogenic) sounds in the ocean, i.e. shipping, commercial and recreational fishing vessels, pile-driving for marine construction, dredging and military activities.

The sound produced during seismic surveys is comparable in loudness to many naturally occurring and other man-made sources. Examples of this are provided in Table 1.

**Table 1: Sound comparisons in air and water**

| Type of Sounds | In Air (dB re 20μPa @ 1m) | In Water (dB re 1μPa @ 1m) |
|---|---|---|
| Threshold of Hearing | 0 dB | 62 dB |
| Whisper at 1 metre | 20 dB | 82 dB |
| Normal conversation in restaurant | 60 dB | 122 dB |
| Ambient sea noise | - | 100 dB |
| Blue whale | - | 190 dB |
| Live rock music | 110 dB | 172 dB |
| Thunderclap or chainsaw | 120 dB | 182 dB |
| Large ship | - | 200 dB |
| Earthquake | - | 210 dB |
| Seismic array at 1 metre | 158-178 dB | 220-240 dB |
| Bottlenose dolphin | - | 225 dB |
| Sperm whale click | - | 236 dB |
| Jet engine take-off at 1 metre | 180 dB | 242 dB |
| Volcanic eruption | - | 255 dB |
| Colliding iceberg | - | 220 dB |

**Source:** www.iagc.org

### *3.1.2.3 The streamers*

The *Polar Duke* will tow 12 streamers for the Toroa 3D MSS. All streamers can be influenced by wind, tides and currents, which can cause feathering, or the streamers to be towed in an arc offset from the nominal sail line.

When the acoustic source is released the streamers detect the very low level of energy that is reflected back up from the geological structures below the seabed using pressure sensitive devices called hydrophones. Hydrophones convert the reflected pressure signals into electrical energy that is digitised and transmitted along the streamer to the recording system onboard the seismic vessel.

Each streamer is divided into sections (50-100 m in length) to allow for modular replacement of damaged components. Solid streamers will be used for the Toroa 3D MSS which are constructed from neutrally buoyant extruded foam. This type of streamer has a number of advantages over fluid filled streamers: they are more robust and resistant to damage (i.e. shark bites); they are less sensitive to weather and wave noise (provides higher quality seismic images); they require less frequent repairs; and they are steerable allowing greater control of the streamers, resulting in less infill lines and reducing the cumulative sound energy introduced into the marine environment.

Towing a streamer underwater removes it from the surface weather and noise which limits the usability of the recorded data and other technical requirements. The deeper the tow depth, the quieter the streamer in regards to weather and surface noise, but this also results in a narrower bandwidth of the data. Typically the range of operating depths varies from 4 – 5 m for shallow high resolution surveys in relatively good weather to 8 – 12 m for deeper penetration and lower frequency targets in more open waters.

At the end of the streamers tail buoys are connected to provide both a hazard warning (lights and radar reflector) of each submerged towed streamer between the tail buoy and vessel, and to act as a platform for positional systems of the streamers (Figure 5). During the Toroa 3D MSS, the *Polar Duke* will be travelling at 4.5 kts so the streamer tail buoy will be travelling approximately 60 minutes behind the vessel.

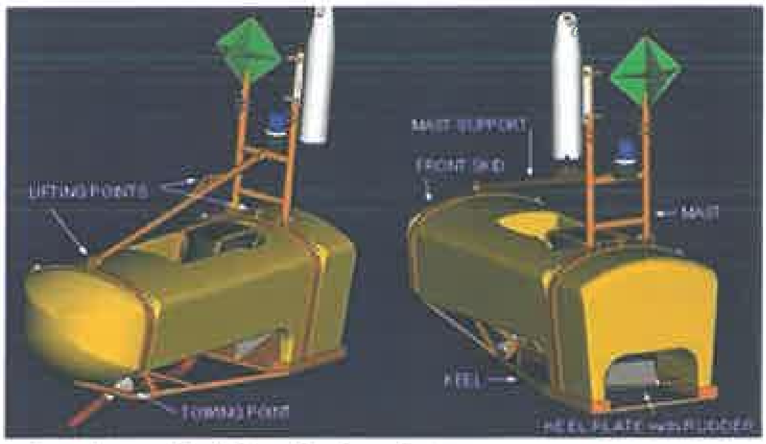


**Figure 5: Example of a tail buoy with light and radar reflector**

## 3.2 Toroa 3D Marine Seismic Survey

The Toroa Survey Area is located to the southeast of Invercargill, over 120 km offshore. This places in the Survey Area on the edge of the continental shelf in deep waters ranging from 750-1250 m depth.

WEL will use the seismic vessel *Polar Duke* and will tow 12 solid streamers, 7 km in length and 100 m apart. The acoustic source will have an effective volume of 3,460 $in^3$ and will be comprised of three sub-arrays with seven acoustic sources on all but one of the sub-arrays, which has nine. The acoustic array will be located at a depth of 7 m below the sea surface and approximately 130 m behind the survey vessel. The depth of the sub-arrays will ensure that the volume used enables the survey to be run effectively in regards to data acquisition, but also to minimise the potential environmental disturbance. In the case of dropouts during acquisition, the gun array may operate at a slightly lower capacity for a short period of time. STLM was conducted by Curtin University and was based on the specific acoustic source volume and operating pressure of the Toroa 3D MSS outlined within this MMIA. The STLM is further discussed in Section 5.1.2.1 and is attached in Appendix 5.

The acoustic source will have an operating pressure of 2,000 psi and will be fired at a sourcepoint interval of 18.75 m apart. For a typical boat speed of 4.5 knots (kts), this equates to a sourcepoint activation every 8 seconds.

The Toroa 3D Survey Area is located within PEP 55794, although both the Survey Area and the Operational Area extends slightly beyond this permit area (Figure 1). WEL are planning to strat the Toroa 3D MSS in February/March 2015 and is scheduled to take approximately 35 days. MSS operations will be conducted 24 hours per day, 7 days per week, subject to suitable weather conditions and marine mammal encounters within the mitigation zones.

The technical specifications of the *Polar Duke* are provided in Table 2. One support vessel (*Sanco Sky*, Figure 7) will be contracted for the duration of the Toroa 3D MSS and will be in close proximity to the *Polar Duke* at all times except if the support vessel has to go into port for supplies. A chase vessel will also be utilised for the duration of the Toroa 3D MSS.

There are four main components involved with the acquisition of the Toroa 3D MSS:

- **Mobilisation of *Polar Duke* to Toroa Operational Area:** After the *Polar Duke* has finished acquiring the Toroa 3D MSS in the Taranaki Basin it will likely make a port call for fuel and a crew change. Following the port call the *Polar Duke* will mobilise to the Toroa Operational Area in the Great South Basin. The *Sanco Sky* will accompany the *Polar Duke* at all times during the passage to the Toroa Operational Area. During transit to the Toroa Operational Area, a MMO will be on the bridge to observe for any marine mammals that would add to the knowledge and distribution of marine mammals around NZ (Section 5.3.2.2);
- **Deployment of Streamer:** The *Polar Duke* will utilise the wind and currents present at the time for the successful deployment of the streamer and acoustic source and will take approximately 72 hours to deploy. Once all the seismic gear is deployed the MMOs will begin pre-start observations as required under the Code of Conduct when arriving at a new location (Section 2.3.2.2). Once these procedures have been followed and adhered to, a soft start can begin for commencement of the Toroa 3D MSS;
- **Data Acquisition:** The *Polar Duke* will follow predetermined survey lines which have been calculated to get the best images from the data and provide greater interpretation of the underlying geology. The two MMOs and two PAM operators on board the *Polar Duke* will monitor for marine mammals throughout the 24 hour period for the duration of the Toroa 3D MSS to ensure compliance with a Level 1 survey under the Code of Conduct; and
- **Demobilisation:** Once the *Polar Duke* has completed the Toroa 3D MSS the seismic array will be retrieved and the vessel will head to its next destination, wherever that may be.

If the vessel has to go on standby during the MSS due to certain adverse weather conditions, it is likely that the acoustic source array would be retrieved to reduce any potential damage, while the streamers may be left deployed.

**Figure 6: Seismic Survey Vessel – *Polar Duke***


**Figure 7: Seismic Support Vessel – *Sanco Sky***

**Table 2: *Polar Duke* Technical Specifications**

| **Seismic Survey Vessel – General Specifications** | |
|---|---|
| Vessel Name | *Polar Duke* |
| Vessel Owner | GCRiber Shipping AS |
| Engine Details | 2 x MAK 9L32/40 MAN Diesel plus 2 x MAK 6L32/40 MAN Diesel |
| Fuel Capacity | 1,820m$^3$ |
| **Seismic Survey Vessel – Dimensions and capacities** | |
| Vessel Length | 106.8m |
| Vessel Beam | 19.2 m at waterline/22 m max |
| Max Draft | 6.5 m |
| Gross Tonnage | 7,689 t |
| Cruising Speed | 17 knots |

**Table 3: Toroa 3D Seismic Specifications**

| Parameter | Specifications |
|---|---|
| Total array volume | 3,460 in$^3$ |
| Acoustic Source | Bolt Longlife |
| Number of sub-arrays | 3 |
| Number of acoustic sources per sub-array | 2 x 7 and 1 x 9 |
| Array length | 15 m |
| Array width | 20 m |
| Nominal operating pressure | 2,000 psi |
| Source Frequency | 2 - 250 Hz |
| Tow depth | 7 m (+/- 1m) |
| Distance from the stern | 130 m |
| Number of streamers | 12 |
| Streamer length | 7,000 m |
| Streamer manufacturer/model | Sercel Sentinel |
| Towing depth | TBC |

## 3.3 Navigational Safety

During the Toroa 3D MSS, the *Polar Duke* will be towing 12 streamers of 7 km in length and in doing so will be restricted in its ability to manoeuvre. At the operational speed of ~4.5 kts during seismic data acquisition and with the large array of streamers being towed, the vessel cannot turn quickly. Therefore, avoidance of collision relies on all vessels obeying the rules of the road at sea and the International Regulations for the Prevention of Collisions at Sea (COLREGS) 1972 which is implemented in NZ under the Maritime Transport Act regime. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the Toroa Operational Area and the presence of the *Polar Duke* and her restriction in ability to manoeuvre while towing the MSS array. The *Polar Duke* has Automatic Identification System (AIS) technology onboard that allows its position to be monitored by other vessels as well as being able to receive the positions of other vessels in surrounding waters to help minimise any risk of collision.

The consultation process has identified all known potential users of that area of ocean, while the presence of the support and chase vessels will be utilised to notify any boats that are unaware of the seismic operations or the vessels that cannot be reached via VHF radio. In accordance with International Maritime Law, the *Polar Duke* will display the appropriate lights and day shapes while undertaking the survey; mainly being restricted in its ability to manoeuvre and towing an array of gear behind the boat. Tail buoys will mark the end of the streamers and these will be equipped with a light and radar reflector for detection both during the day and night.

## 3.4 Analysis of Alternatives

Most seismic surveys conducted worldwide use acoustic sources, as they generate low frequency signals which can image the underlying geology several kilometres below the seafloor. Each component of the Toroa 3D MSS is required to not only gather the best information from the underlying geology and hydrocarbon potential within the Toroa Operational Area but to also reduce any adverse effects on the marine environment to the fullest extent practicable.

WEL will use a 'bolt acoustic source' for the Toroa 3D MSS, with the acoustic source consisting of three sub-arrays. The energy source and acoustic source array configuration was selected so that it provides sufficient seismic energy to acquire the geological objective of the survey, whilst minimising the environmental disturbance through limiting excess noise to the environment.

As part of the Toroa 3D MSS design, WEL has identified the source size necessary to adequately record data from a pre-determined depth. A source volume of 3,460 $in^3$ was identified as an optimum volume given the water depths and geology for the survey to achieve its objectives. Larger source volumes available onboard the *Polar Duke* were not selected in the interest of minimising unnecessary noise being released into the marine environment.

The acquisition period for the Toroa 3D MSS will utilise the settled summer period to reduce weather-induced down-time to ensure that the survey duration is as short as possible. With the current MSS schedule, the survey will be completed prior to the northwards migrating humpback whales from the Southern Ocean feeding grounds.

# 4 Environmental Description

## 4.1 Physical Environment

### 4.1.1 Meteorology

New Zealand's climate is complex and varies from warm subtropical in the far north to cool temperate in the far south. Anticyclones are a major feature of the weather in the Australian-NZ region. These circulation systems migrate eastwards across NZ every six to seven days with their centres generally passing across the North Island. Overall, anticyclones follow northerly paths in the spring and southerly paths in the autumn and winter.

Troughs of low pressure orientated northwest to southeast, and associated cold fronts are found between the anticyclones. As these cold fronts approach from the west, northwesterly winds become stronger and cloud levels increase. A period of rain lasting up to several hours will follow while the front passes over. After the front has gone through, the weather conditions change again, this time to cold showery southwesterly winds.

The stretch of coastline adjacent to the Toroa Operational Area is located within the "Southern New Zealand Climate Zone" as defined by NIWA (NIWA, 2014). This zone is typically cool and dominated by southwesterly winds. Daytime temperatures range between 16°C and 23°C in the summer months and drop to between 8°C and 12°C in the winter.

Mean monthly weather parameters for Dunedin have been used as indicative for the Toroa Operational Area (Table 4).

**Table 4: Mean Monthly weather parameters at Dunedin**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 42 | 47 | 47 | 57 | 30 | 37 | 44 | 38 | 32 | 44 | 41 | 72 |
| Temp – avg. daytime (°C) | 22 | 21 | 19 | 16 | 14 | 11 | 11 | 12 | 15 | 16 | 19 | 20 |
| Temp – avg. night time (°C) | 8 | 8 | 6 | 4 | 2 | -1 | -1 | 0 | 2 | 3 | 6 | 8 |
| Avg. wind speed (kts) | 12 | 13 | 11 | 11 | 10 | 11 | 10 | 11 | 13 | 14 | 15 | 14 |
| Max. wind speed (kts) | 54 | 65 | 56 | 59 | 57 | 56 | 52 | 57 | 63 | 67 | 65 | 48 |

**(Weather2, 2014)**

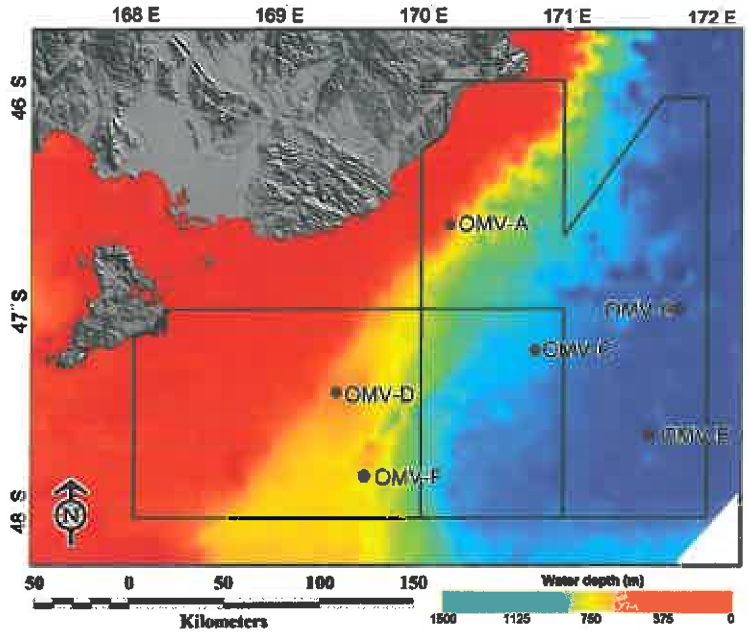


**Figure 8: Locations for summary metocean conditions provided in the MSL report (2011).**

The Metocean Solutions Ltd (2011) report provided summary of metocean conditions for a number of sites in and around the GSB. For the purpose of this MMIA, we will use OMV-E as representative of conditions within the Toroa Operational Area (see Figure 8). Monthly mean annual wind speeds for OMV-E can be found in Table 5. These wind speeds peak in the winter month reaching a maximum average speed of 9.32 m/s in June. Minimum average wind speeds have been recorded in January (7.87 m/s).

**Table 5: Monthly mean wind speed at OMV-E**

| Month | Wind speed (m/s) |
|---|---|
| January | 7.87 |
| February | 8.31 |
| March | 8.35 |
| April | 8.92 |
| May | 8.85 |
| June | 9.32 |
| July | 8.46 |
| August | 8.67 |
| September | 8.78 |
| October | 8.49 |
| November | 8.63 |
| December | 8.04 |

The MSL report also demonstrates a well-defined wind gradient across the bottom of the south Island with, on average, stronger winds in the southwestern portion of the GSB. Additionally, there is evidence of storms centred on the eastern and northern sector of the GSB. The vector-average wind speed/direction map clearly illustrates a predominance of westerly-sector winds across the south of New Zealand and the GSB as does the wind rose (see Figure 9 and Figure 10) (Metocean Solutions Ltd, 2011).

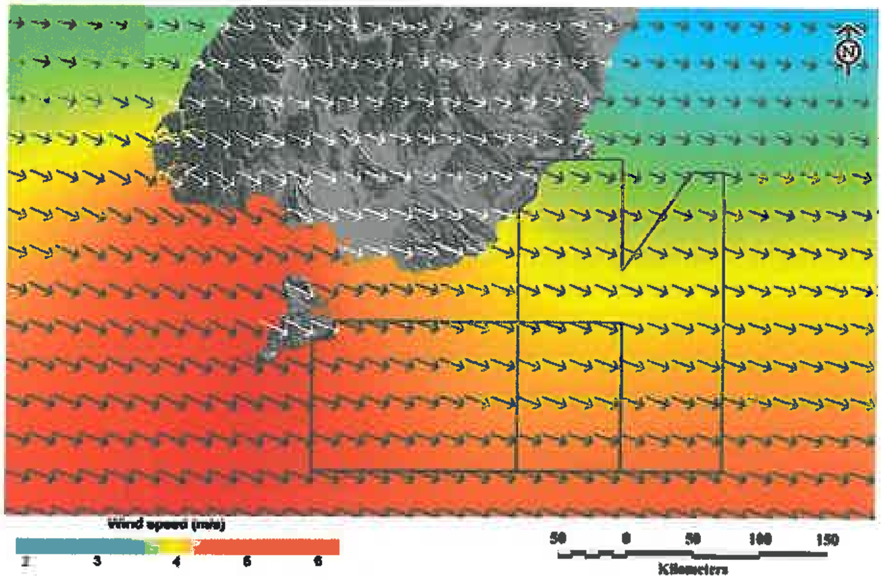


**Figure 9: Vector-average wind speed and direction**

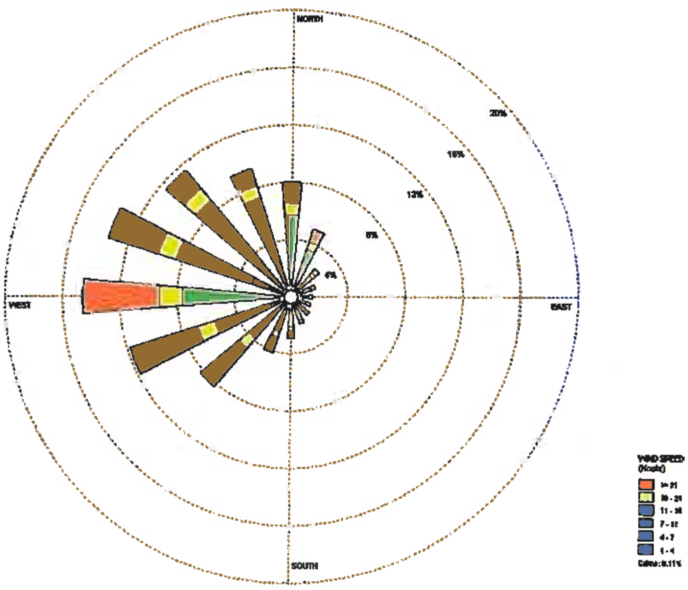


**Figure 10: Annual wind rose for site OMV-E**

### 4.1.2 Oceanography

#### *4.1.2.1 Current Regime*

Around the NZ coastline, the current regime is dominated by three different components: wind-driven flows, low-frequency flows and tidal currents. The net current flow is a combination of all three of these components and is often further influenced by the local bathymetry.

NZ lies in the path of eastward-flowing currents, which are driven by winds that blow across the South Pacific Ocean. This results in NZ being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the

Roaring Forties westerly winds to the south (Gorman *et al.*, 2005). The anti-clockwise circulation of the gyre is initiated by the winds but is then further modified by the spin of the earth (Coriolis Effect).

On the west coast of the South Island of NZ, the general eastward flow of the Tasman sea is split into the Westland current which progresses northeast along the west coast of NZ and the Southland Current which is deflected through the Foveaux Strait, around Stewart Island, and along the east coast of NZ towards the Chatham Rise (Brodie, 1960). Long thought to be limited to a narrow coastal band (Chiswell, 1996), the Southland Current is now known extend 130 km offshore (Sutton, 2003). This pronounced northeasterly flow will be the dominant current within the Toroa Operational Area (Figure 11).

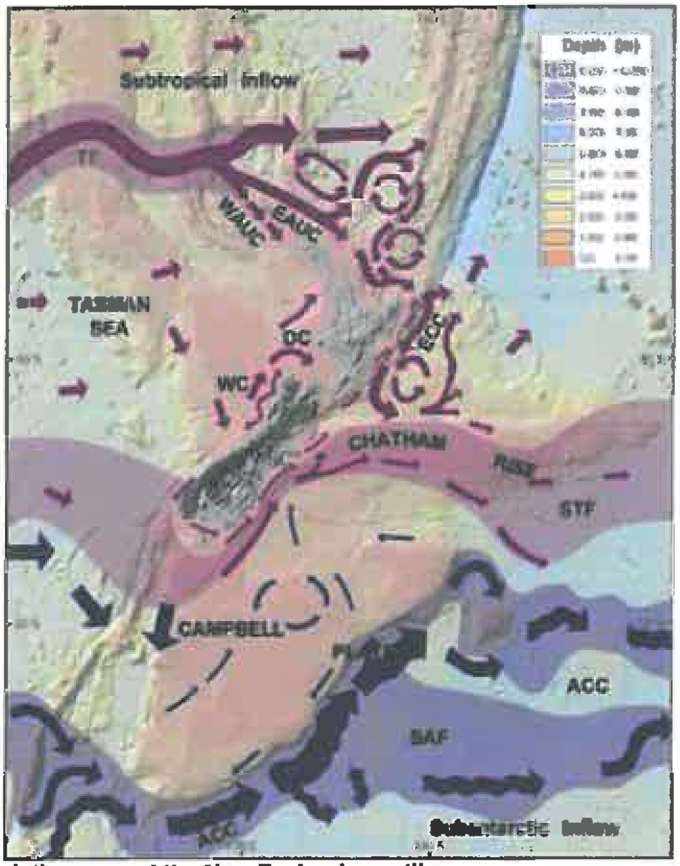


**Figure 11: Ocean Circulation around the New Zealand coastline**
(Source: http://www.teara.govt.nz/en/map/5912/ocean-currents-around-new-zealand)

Results from the ROMS modelling of non-tidal currents included in the 2011 MSL report (Metocean Solutions Ltd, 2011) illustrate the presence of the Southland current along the southeastern coast of the South Island. At the surface, the Southland current forms a band of flow following the main bathymetric features (see Figure 12). Mean current speed in this band is 0.6 m/s and maximum speed is 2.3 m/s. Surface speeds taper away from the Southland current and an area of weaker flow exist southeast of Stewart Island.

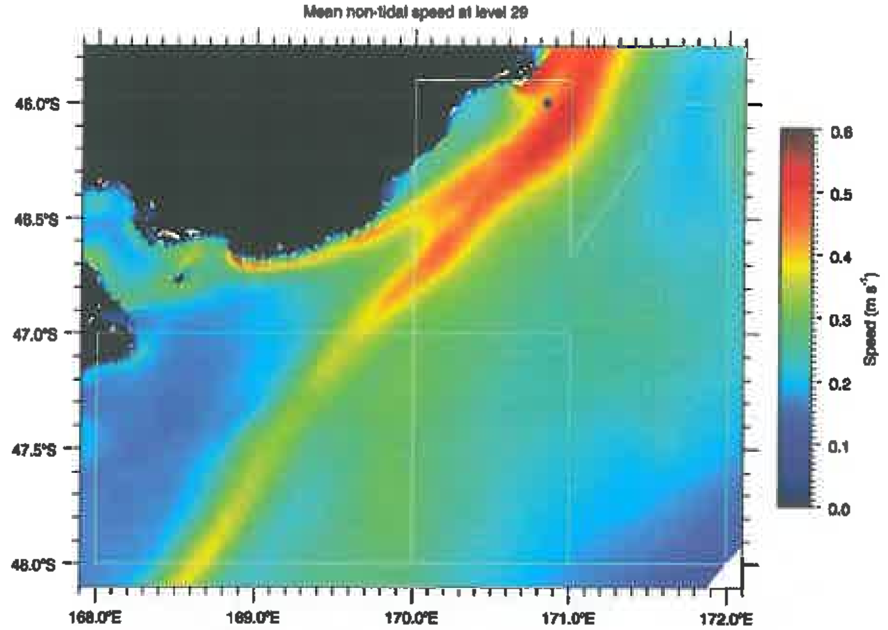


**Figure 12: Mean surface current speed from the ROMS model**

Overall, mid-water currents exhibit a similar pattern to surface currents although slightly weaker (see Figure 13). The Southland Current at these depths is constrained to the coast except for a northeast-southwest band along the edge of the continental shelf.

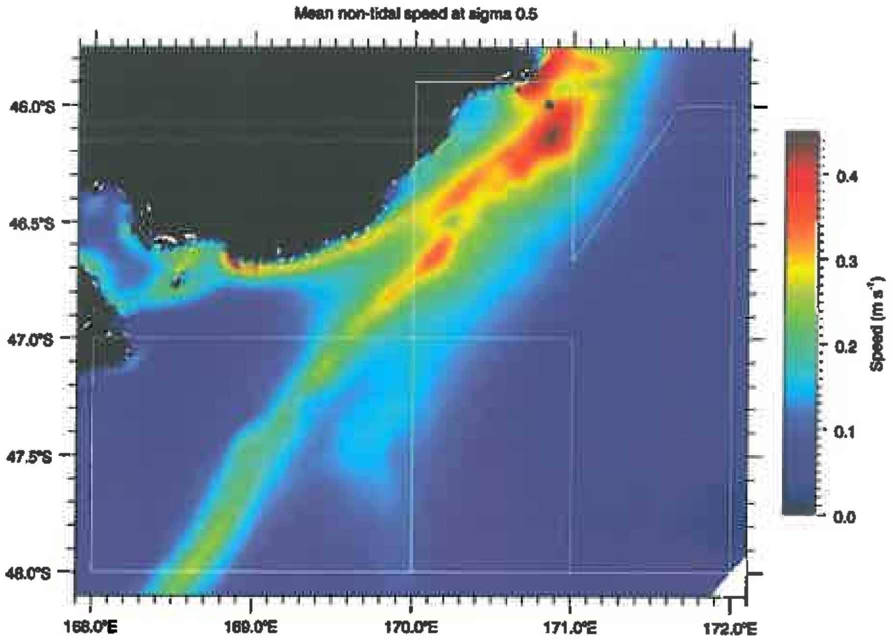


**Figure 13: Mean mid-water current speed from the ROMS model**

At the bottom of the water column, the Southland current further contracts towards the coastline. At these depths, areas of increased flow could indicate the location of canyons (see Figure 14).

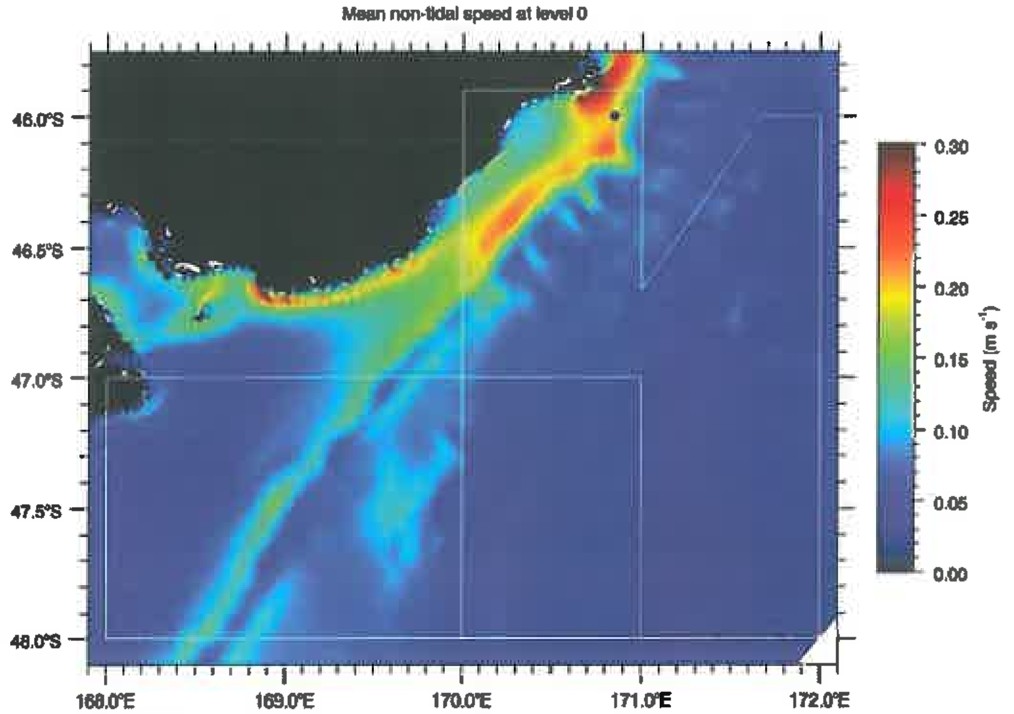


**Figure 14: Mean bottom current speed from the ROMS model**

#### *4.1.2.2 Thermoclines and Sea Surface Temperature*

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

The Toroa Operational Area is located within the Southland Front. This is a prolongation of the subtropical convergence and results from the meeting of subtropical (warmer and more saline) and subantarctic waters (colder and less saline). As a result, strong variations in salinity and temperature occur in this area and are particularly pronounced over the continental shelf to the east of the South Island. In summer, inshore surface waters can present a 2°C difference with offshore waters. In addition, surface coastal waters are also influenced by riverine run-off (e.g. Clutha River) which can affect both the salinity and surface temperature of the water (Vincent & Howard-Williams, 1991). Figure 15 and Figure 16 from Metocean Solutions Ltd (2011) clearly show the gradient in temperature between the warm coastal waters and the cooler off shore waters off the south of the South Island and across the GSB.

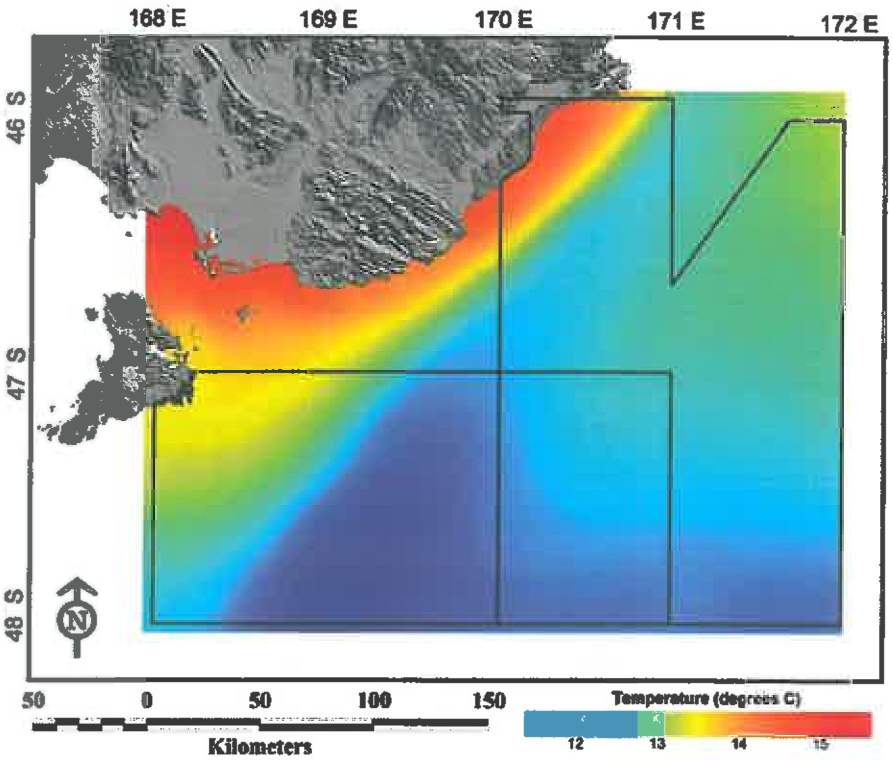


**Figure 15: Mean February sea surface temperatures**

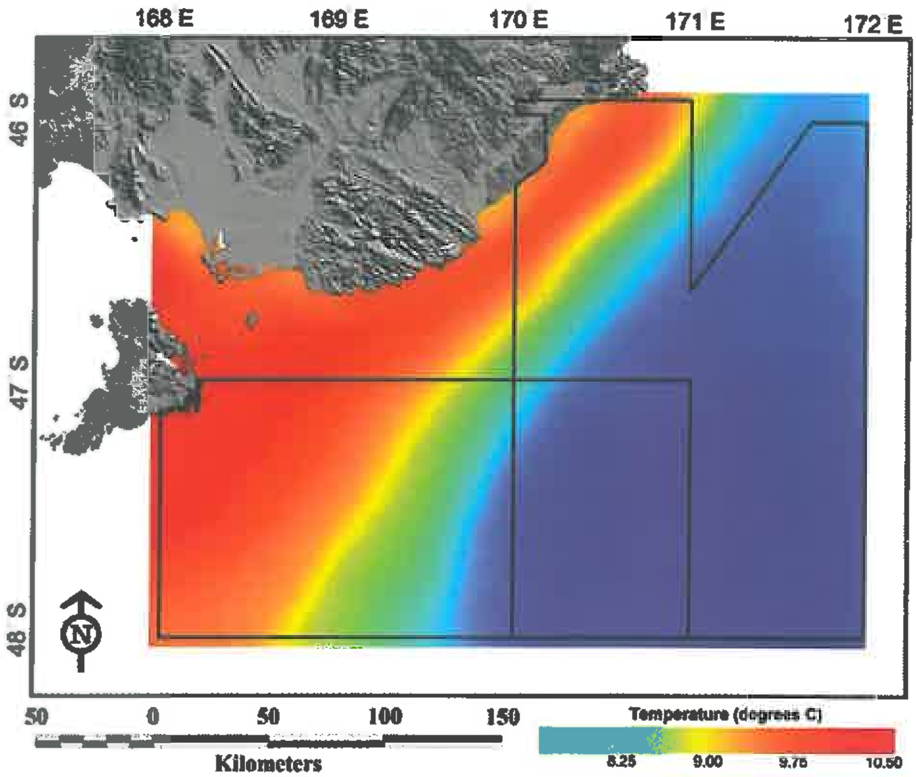


**Figure 16: Mean August sea surface temperature**

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

#### *4.1.2.3 Wave Climate*

The wave climate in the Great South Basin is characterised by waves averaging between 2 and 3 meters (Figure 17). Maximum average wave height at OMV-E is reached in June (2.92 m), whereas minimum average wave height is reached in December (2.06 m) (Table 6). Waves within the Great South Basin are predominantly from the southwest quarter (over 60% of waves) (Figure 18) (WEL, 2014).

**Table 6: Mean monthly wave height in the Great South Basin**

| Month | Mean wave height (m) |
|---|---|
| January | 2.1 |
| February | 2.3 |
| March | 2.49 |
| April | 2.84 |
| May | 2.86 |
| June | 2.92 |
| July | 2.84 |
| August | 2.82 |
| September | 2.72 |
| October | 2.54 |
| November | 2.33 |
| December | 2.06 |

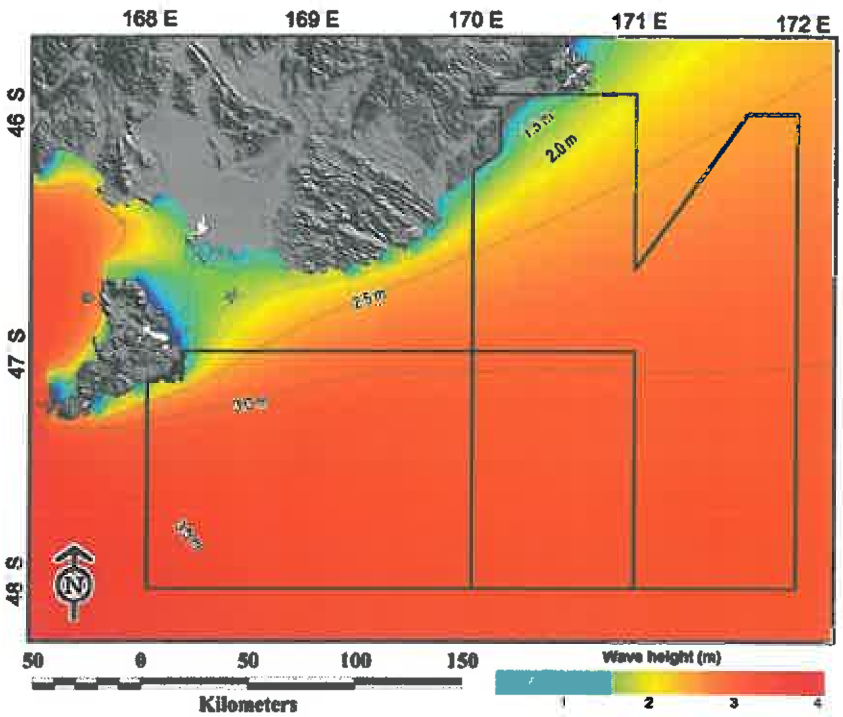


**Figure 17: Mean significant wave height (1998-2007)**

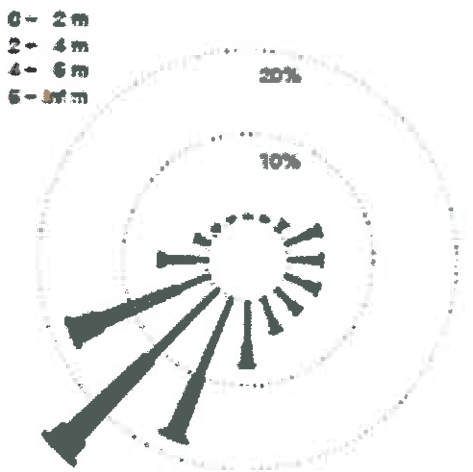


**Figure 18: Wave rose plot derived for PEP 55794**

### 4.1.3 Bathymetry and Geology

#### *4.1.3.1 Bathymetry and Geology of New Zealand*

As is the case of every major land mass, New Zealand is surrounded by a flat, gently sloping zone known as the continental shelf. It extends from the coast out to a water depth of approximately 100 – 200 m. Beyond the continental shelf, the gradient of the seabed steepens and passes into the continental slope which descends relatively rapidly from the edge of the shelf down to depths greater than 4,000 m. At the foot of the slope, the seaward gradient flattens out into the ocean basins which are constituted by a wide, undulating, but relatively flat zone lying at 4,000 to 5,000 m depth and cover most of the central parts of the major oceans (Te Ara, 2014a).

The surface of the continental shelf is predominantly flat although diversified by local banks and reefs, whereas the slope is more irregular and cut in many areas by large marine valleys known as submarine canyons. These tend to occur in slope areas of relatively steep gradient and generally run from the edge of the continental shelf to the foot of the continental slope. The Toroa Survey Area spans the continental slope, where the inshore section of the survey area is on the 750 m depth contour, while the seaward extent of the Toroa Survey Area is located in water depths of 1,250m (Figure 19).

The width of New Zealand's continental shelf varies from one area to another. The narrowest parts are found off the east coast between Kaikoura and Cape Kidnappers (1-15 Nm in width), and off Fiordland (1-4 Nm in width). Other areas of New Zealand generally have a more extensive continental shelf of up to 40 Nm wide. The western Cook Strait and the southern coast of Stewart Island have the widest continental shelves of all which exceed 100 Nm in width (Te Ara, 2014a).

This varied underwater topography is the result of Zealandia's breakup from Gondwana (~85 million years ago) which created the continental slopes, opened the Tasman Sea floor and created sedimentary basins. Rivers eroded the land and transported sediments containing organic matter into these basins. This resulted in shoreline sands being deposited, followed by marine silts and mud several kilometres thick which were compacted by the weight of the overlying sediment. Due to being both porous and permeable, these materials made ideal reservoir rocks, while the impermeable overlying silts, mud and carbonates formed the seals.

There are eight of these sedimentary basins around New Zealand (Figure 20) both onshore and underlying the continental shelf, with known or potential hydrocarbons present. However, commercial quantities of oil and gas have only been produced from the Taranaki Basin. In addition to these continental sedimentary basins, there are also several deep-water basins offshore (Figure 20).

The New Zealand's sedimentary basins can be subdivided into 'Petroleum Basins' and 'Frontier Basins'. The petroleum basins are based on modern, industry-standard seismic surveys over at least a part of each basin or from well logs. As a result, all or part of each petroleum basin has been licensed for exploration.

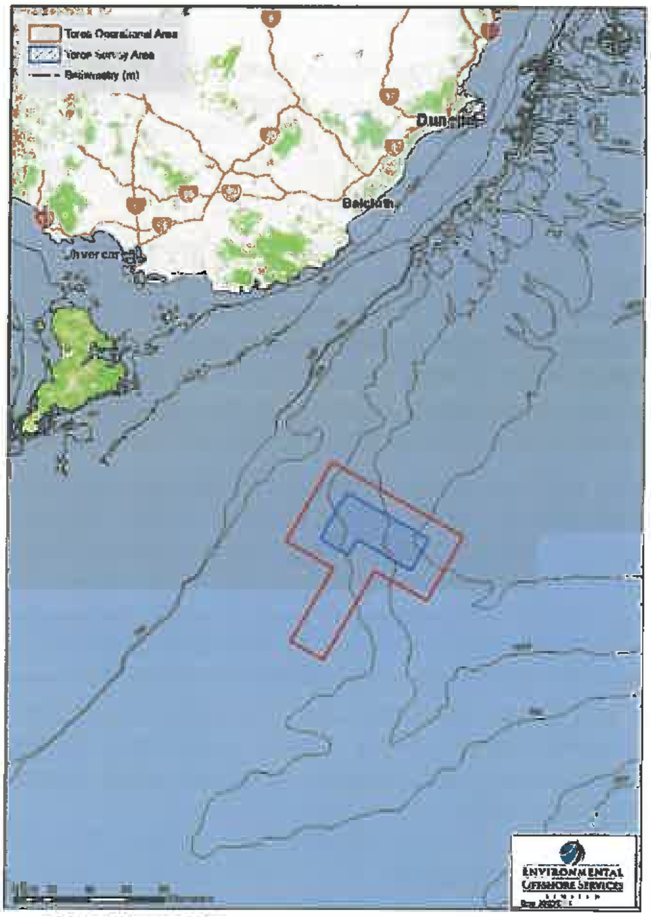


**Figure 19: Bathymetry map of the Toroa Operational Area**


**Figure 20: NZ Sedimentary Basins.**
(Source: GNS)

#### *4.1.3.2 The Toroa Operational Area*

The Toroa Operational Area sits astride a steep continental slope in the Great South Basin. As a result, water depths vary considerably, ranging from approximately 600 m in the northwestern sector of the operational area to over 1,000 m in the southeast. Beyond the boundaries of the Toroa Operational Area, the Great South Basin continues to extend southeast to depths of approximately 1,500 m.

The Great South Basin occupies the site of the late Mezosoic extension of the landward side of the Gondwana margin. Tectonic movement (faulting) during the subsequent Cretaceous period resulted in the development of fluvial systems parallel to the grabens axes. These systems became the dominant factor in sedimentary deposition in the basin and persisted particularly on the western edge of what is now the Great South Basin. The western edge was also affected by the deformation caused by the propagation of the modern plate boundary resulting in a series of structural folds (anticlynes and synclynes).

Coastal basement rocks originate from a number of different terrains. These giant crustal slabs can comprise sedimentary, plutonic, and volcanic rocks. Around NZ, the terrains are grouped into the Palaeozoic (540-300 million years ago) Western Province, and the Permian to early Cretaceous (300-100 million years ago) Eastern Province. The boundary between these two provinces is a zone of volcanic arc rocks which forms part of the coastline of central Southland and northern Stewart Island. To the west of this boundary, Southland and Stewart Island coastlines are generally rocky granite Western Province terrains, whereas to the east, the Catlins and Otago coastline are greywacke (hardened sandstone) Eastern Province terrains. In some areas of the Otago coast and Stewart Island, increased temperature and pressure caused the creation of schist which was then pushed up from great depths (Morton & Miller, 1968).

## 4.2 Biological Environment

### 4.2.1 Plankton

The productivity of the ocean is the result of many factors; namely ocean currents, climate and bathymetry which cause upwelling and create nutrient rich waters – ideal conditions for plankton growth and the animals that feed on them (MPI, 2014b).

Plankton are drifting organisms (animals, algae, protists, archaea or bacteria) that occupy the pelagic zone of oceans, seas or bodies of fresh water around the world. Plankton are the primary producers of the ocean which places them at the bottom of the food chain. They travel passively with the ocean currents although some plankton species can move vertically within the water column. Nutrient concentrations, seasonality and the physical state of the water column (i.e. settled or well-mixed) influence the abundance of plankton. There are three broad functional groups for plankton:

- Bacterioplankton – play an important role in nutrient cycles within the water column;
- Phytoplankton – are the primary producers of the ocean. They are microscopic plants which capture energy from the sun and take in nutrients from the water column via photosynthesis. They create organic compounds from $CO_2$ dissolved in the ocean and help sustain the life of the ocean; and
- Zooplankton – consist of small protists, metazoans (i.e. crustaceans), larval stages of fish and crustaceans which feed on the phytoplankton and bacterioplankton. Although zooplankton are predominantly transported by ocean currents, many are able to move, generally to either avoid predators or to increase prey encounter rates.

It is widely accepted that high levels of primary productivity can have a knock-on effect up the food chain, attracting predators to feed in the area. In recent years, satellite imagery has been used to examine this phenomenon in the oceans around New Zealand (using chlorophyll α as a proxy for primary productivity). These images show evidence of seasonal and regional variation of chlorophyll α and highlights the importance of the Southland Front for the region and its influence on the diversity and abundance of planktonic species present in the area.

Within the coastal subtropical waters, a consistent annual phytoplankton bloom takes place during the spring months (Murphy *et al.*, 2001). Chlorophyll α levels then proceed to drop to their lowest annual level at the end of the summer, and build up throughout the winter in order to peak once again with the onset of spring. In addition to this seasonal cycle, it has also been noted that riverine discharges (Clutha and Taieri Rivers) can have a marked effect on chlorophyll α concentrations along the southeastern coast of NZ. The nutrients contained within these waters have been seen to boost primary productivity over an area reaching several kilometres from the coast (Haywood, 2004).

This annual cycle weakens markedly in the offshore subantarctic waters where only small variations in primary productivity concentrations take place with the exception of local phytoplankton accumulations around the Snares Plateau and Pukaki Rise (Murphy *et al.*, 2001).

In addition to seasonal variations linked to primary productivity, the structure of the zooplankton community in the vicinity of the Toroa Operational Area is also affected by the local current regime and frontal system. Jillett (1976) recognised the existence of neritic "coastal" and "shelf" zooplankton groups and oceanic "transitional" and "subantarctic" zooplankton groups.

### 4.2.2 Invertebrates

NZ has a large diversity of marine invertebrates. This is attributable to the variable seafloor relief and NZ's ancient geological history. From the intertidal to the deep sea trenches, each habitat hosts a unique combination of species which are adapted to the local environmental conditions (i.e. temperature, currents, salinity, local geology, food availability etc.).

The coastal area closest to the Toroa Operational Area (i.e. south Otago and south Southland which lie at a minimum distance of 120 km from the Toroa Operational Area) is part of a cold temperate marine biogeographic zone called the Cookian Province. This zone is characterised by the prominence of bull kelp (*Durvillea antarctica*), algae such as *Cystophora, Marginariella* and *Demestia* which are only found around the coasts of the South Island, and *Apophlea lyallii, Adenocystis utricularis* and *Gigartina sp.* which are limited to the southern end of the South Island. Within the eulittoral zone, blue, ribbed and green lipped mussels are prominent, as is *Ostra lutaria* (rock oyster) south of Dunedin. The limpet *Cellana strigilis redimiculum,* is also common around the Otago, Southland and Stewart Island coastlines. Overall, molluscs present in the area adjacent to the Toroa survey area have a subantarctic element and include families such as *Gaiamardiidae, Cyamiidae, Philobyidae, Margareall, and Kerguelenella*. This Subantarctic influence is further felt in the limited number of species observed in the area. This low species diversity (typical of colder climates) is compensated for by high abundance of each species.

As in other areas of NZ, molluscs tend to dominate rocky shores, while mobile invertebrates are most commonly observed in soft shores. On hard shores, sessile invertebrate species (i.e. sponges, ascidians, bryozoans, and hydroids) are conspicuous and form stable communities (Lavery *et al.*, 2007). However, the Toroa Survey Area is located approximately 120 km from the coastline, and as a result will not have any influence on these coastal environments.

Similarly to the intertidal, the deeper subtidal and abyssal zones within the Toroa Operational Area present a wide range of habitats, at a range of depths (from the photic zone to the abyssal depths) and in a range of current, salinity and temperature conditions. This contributes to the occurrence of complex and varied assemblages of invertebrate species.

NZ has a rich and diverse range of corals that are present from the intertidal zone down to 5,000 m (Consalvey *et al.*, 2006). They can live for hundreds of years and exist either as individuals or as compact colonies of individual polyps. Deep-sea corals are fragile, sessile, slow growing and long-lived. They have limited larval dispersal and are restricted to certain habitats.

The conservation of deepwater corals (also known as cold water corals) is of particular concern as these organisms are at risk from number of anthropogenic activities (fishing, mining etc.). As a result, all deepwater black corals, gorgonians, stony corals, and some hydrocorals have been listed as protected species under the 2010 amendment to Schedule 7A of the Wildlife Act 1953.

Stylasterid corals are known to occur in the general Toroa Operational Area from direct sampling which has taken place in the region (Figure 21), however the number and nature of samples is insufficient to provide a full picture of the occurrence of cold water corals in general. Consequently, in 2013, NIWA used models to predict the occurrence of gorgonians, hydrocorals, black corals and stony corals in NZ waters (Baird *et al.*, 2013). The results suggest a generally high occurrence of gorgonians and stony corals within the Great South Basin and a low occurrence of black corals.

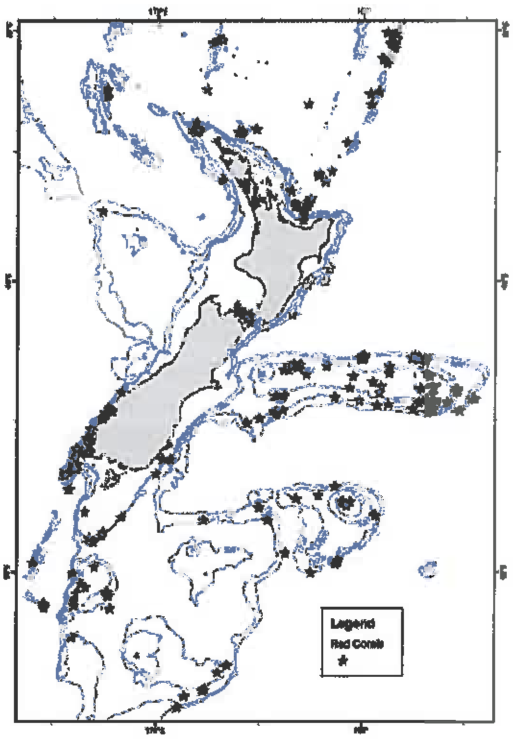

**Figure 21: Known localities of stylasterid coral within the New Zealand region**
(Source: Consalvey *et al.*, 2006)

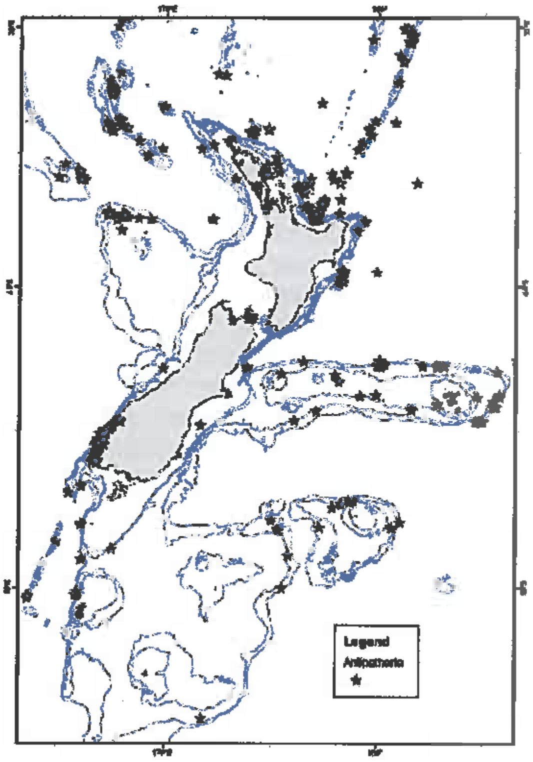


**Figure 22: Known localities of black coral within the New Zealand region**
(Source: Consalvey *et al.*, 2006)

### 4.2.3 Fish Species

The southeast coast of New Zealand provides habitats for a number of demersal and pelagic species ranging from shallow to deep waters. General distribution for these species are listed in Table 7.

MPI prepared a fisheries assessment for all fishing effort within the Toroa Operational Area that has occurred during 2008-2013. This assessment identified that Hoki was the most commonly caught commercial fish species within this area. More detail on commercial fishing within the Toroa Operational Area can be found in Section 4.4.2.

**Table 7: Distribution of fish species occurring in and around the Toroa Operational Area (MPI, 2013, 2014f)**

| Water column | Fish species |
|---|---|
| Demersal | Alfonsino, banded stargazer, barracouta, bass, baxter's lantern dogfish, black cardinal fish, black flounder, black oreo, blue cod, blue mackerel, blue moki, blue warehou, bluenose, bollon's rattail, butterfish, dark ghost fish, elephant fish, eels, four-rayed rattail, frostfish, garfish, gemfish, ghost shark, giant stargazer, green-back flounder, grey mullet, groper, hapūku, hoki, jack mackerel, javelin fish, john dory, johnson's cod, kingfish, lamprey, leatherjacket, lemon sole, ling, lookdown dory, marblefish, Murphy's mackerel, notable rattail, NZ sole, orange roughy, pale ghost shark, rays, red cod, red gurnard, red moki, red snapper, redbait, ribaldo, rig, rough skate, rubyfish, pilchard, sand flounder, school shark, sea perch, seal shark, serrulate rattail, shovelnose dogfish, silver dory, silver warehou, smooth skate, spiky oreo, spiny dogfish, spotted stargazer, squid, tarakihi, trevally, turbot, two saddle rattail, white rattail, white warehou, wrasse, yellow-bellied flounder. |
| Pelagic | Albacore tuna, basking shark, blue shark, broadbill swordfish, bronze shark, hammerhead shark, herring, kahawai, mako shark, marlin, moonfish, pacific bluefin tuna, pilchard, porbeagle shark, ray's bream, ruby fish, seven gilled shark, southern blue whiting, southern bluefin tuna, sprat, thresher shark, trumpeter, white pointer. |

#### *4.2.3.1 Protected fish species*

Schedule 7A of the Wildlife Act 1953 lists eight species of fish as protected. The list includes basking shark, deepwater nurse shark, great white shark, manta ray, oceanic white-tip shark, spiny-tailed devil ray, spotted black grouper, and whale shark. Additionally, the great whites, basking sharks and oceanic white-tip sharks are also protected under the Fisheries Act which prohibits NZ flagged vessels from taking these species, even beyond the NZ EEZ. Two of these species could occur within the Toroa Operational Area: the great white shark and the basking shark.

Great white sharks occur throughout NZ waters, including the Toroa Operational Area and are at risk of extinction worldwide. They are classified as being in gradual decline under the NZ Threat Classification System and as "vulnerable" by the IUCN Red List of Threatened Species.

NIWA have played a key role in setting up a shark satellite tagging programme in NZ and 35 great white sharks have been tagged since 2005. The resulting data have demonstrated that NZ great whites migrate seasonally from March to September, between aggregation sites at Stewart Island and the Chatham Islands, to the tropical and subtropical Pacific (i.e. northern New South Wales and Queensland, Norfolk Island, New Caledonia, Vanuatu, Fiji and Tonga). However, they don't appear to cross the equator (DOC, 2014j). Stewart Island great white sharks tend to head northwest of NZ, while the great white sharks tagged at the Chatham Islands head north to warmer waters.

Basking sharks are known to be more common in colder waters south of 39°S, so there is the potential that these pelagic filter-feeders could be attracted to the coastal areas in the Southland region which have high plankton productivity during the spring and summer (DOC, 2014a). As a result this species could occur within the Toroa Operational Area.

### 4.2.4 Cetaceans

Fifty-one species of dolphins and whales can be found in NZ, which is over half of the world's cetacean species (Suisted & Neale, 2004). Taxonomically, cetaceans are split into two suborders: toothed whales (odontocetes) and baleen whales (mysticetes).

Baleen whales are often large; they don't have teeth; and they have a fringe of stiff hair-like material, or baleen, hanging from their upper jaw which they use to filter small animals out of the seawater. In contrast, odontocetes have teeth; they are highly social; and they hunt and navigate in large groups. An additional difference between the mysticete and odontocete suborders is the way in which these animals use sound. While both groups use sound to communicate (at varying frequencies depending on the species), only odontocetes echolocate. Odontocetes direct sound ("clicks") into their environment and use the reflected sound waves to explore their surroundings and identify objects or locate prey. This reliance on sound to communicate and feed makes cetaceans vulnerable to the effects of anthropogenic underwater noise and precautions must be taken during seismic surveys in order to keep impacts to a minimum. Mitigation measures specific to the Toroa 3D MSS are discussed in Section 5.3.

Cetaceans are elusive creatures which are notoriously difficult to study. Gathering data on deep-diving, offshore and migratory species presents numerous logistical problems and on the whole these are the species that are less well documented. Since distribution data is not necessarily available for all species in all areas, it is important to consider multiple sources of information in order to build an accurate picture of cetacean occurrence. Information is generally available in the form of detection data (acoustic detections or sightings from dedicated and opportunistic surveys) or can be inferred from strandings information, knowledge of migration paths and habitat preferences of each species.

In addition, caution should be exercised when interpreting sightings datasets from multiple sources. Importantly, the lack of sightings data in an area does not strictly indicate an absence of cetaceans. A lack of sightings data can, in fact, be an indicator of limited observer effort caused by a low level of boat activity in the area, infrequent dedicated surveys with few or no sightings, or the relative inaccessibility of the area in question. Further, a lack of sightings data could simply be caused by a lack of reporting to the main DOC databases which are referred to in this report.

Similarly, strandings data must also be interpreted with care. Strandings can give a very broad indication of occurrence and information on life history of a species (via stomach contents etc.) but, without the assistance of complex models, will only yield limited indications on species distribution. These data should be considered as a complement to detections (acoustic and visual) of live animals.

As mentioned above, where cetacean detections or stranding data are limited or lacking, information on life history, habitat preferences and migratory pathways can be used to infer species occurrence. In particular, seasonality is important in determining which species will be present in an area at a given time of year. Some cetacean species are resident and present year-round whereas others will migrate to an area either to reproduce or forage following migratory paths every year.

This MMIA aims to provide a broad overview of cetaceans which could be present in the Toroa Operational Area. However, the available data for some species is limited due to logistical limitations mentioned previously. Consequently, the cetacean sightings data collected during the Toroa 3D MSS will be invaluable towards enhancing available baseline information within the Toroa Operational Area and in turn will contribute to effective monitoring of vulnerable species.

#### *4.2.4.1 Sightings and strandings within and surrounding the Toroa Operational Area*

The data sources accessed in order to identify cetaceans potentially present within the Toroa Operational Area include the National Aquatic Biodiversity Information System (NABIS), the DOC sighting database, the DOC stranding database and readily available literature.

The DOC sighting database, current up until February 2014 had the geographical positions of 8,343 sightings of marine mammals, of which numerous records contributed by previous MSSs around the NZ coastline (Figure 23).

The DOC stranding database has also been accessed up until the end of 2013 and plotted on GIS mapping software. A summary of the DOC stranding database was undertaken by Brabyn (1991) where at that time of writing 88% of the 1,140 whale strandings in NZ comprised of three species; pilot whales, false killer whales and sperm whales.

The cetacean species identified within these sources are listed in Table 8 and a basic ecological summary for each of the more common species likely to be within the Toroa Operational Area is included in Section 4.2.4.4.

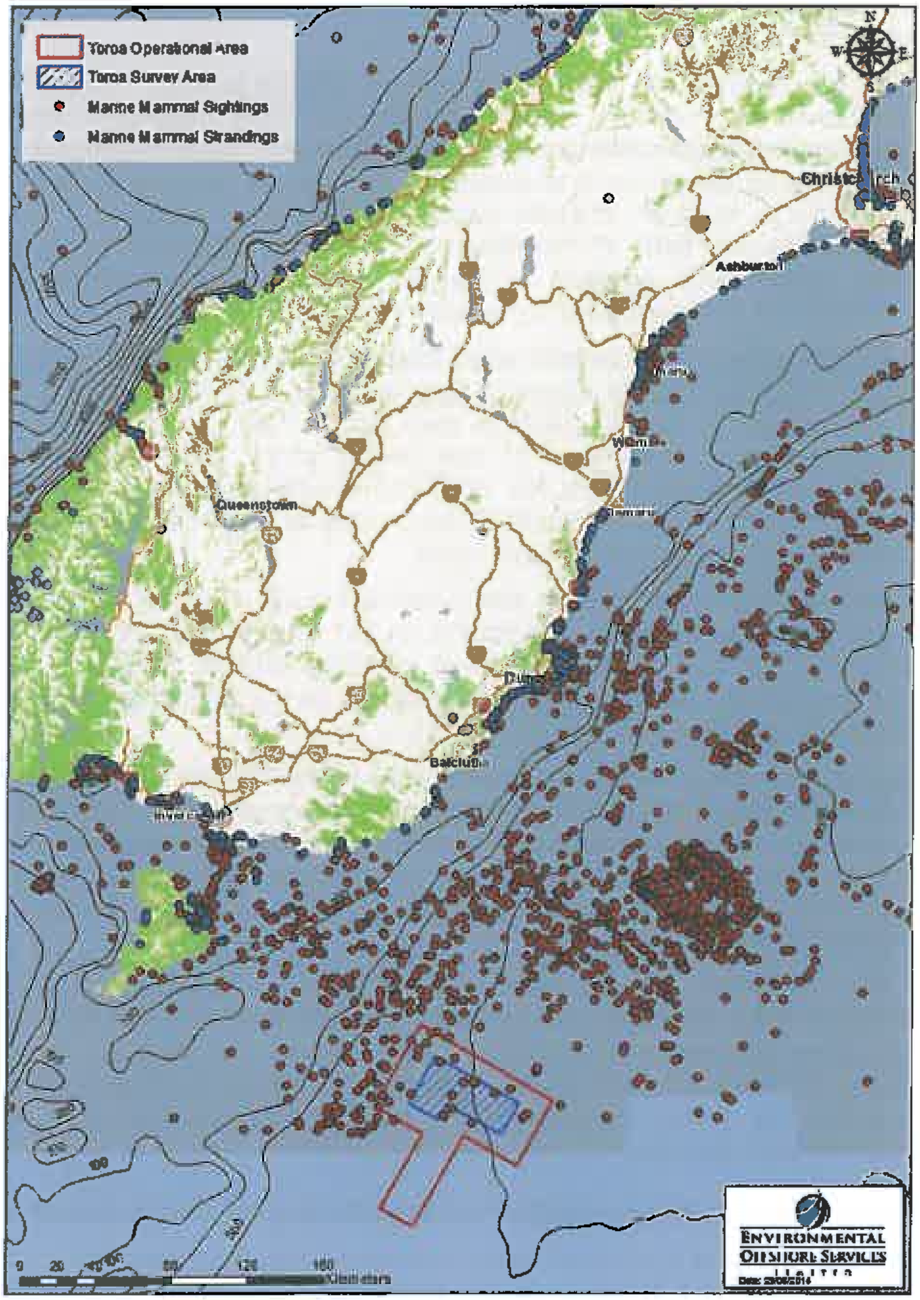


**Figure 23: Marine mammal sightings and strandings. Data sourced from the DOC stranding database.**

**Table 8: Cetacean species occurring in and around the Toroa Operational Area**

**Note:** Common occurrence in the operational area = located within the core species range; Rare occurrence in the operational area = located in the species full range; vagrancy in the operational area = the operational area is adjacent to the species range but individuals may stray into the operational area; Good data availability = repeated sightings and/or monitoring, strandings data, ecological characteristics are known; Moderate data availability = few sightings, strandings data, ecological characteristics are known; Poor data availability = strandings data, ecological characteristics are known.

| Species | Distribution | Residency pattern in wider area | Occurrence in Toroa Operational Area | Critical life cycle behaviour in Toroa Operational Area | Protection status | Data availability for the wider area |
|---|---|---|---|---|---|---|
| Blue whale (Balaenoptera musculus) | Offshore | Migrant | Common | Migration | IUCN endangered | Moderate |
| Humpback whale (Megaptera novaeangliae) | Offshore | Migrant | Common | Migration | IUCN least concern | Good |
| Pilot whale (*Globicephala melas*) | Offshore | | Common | Feeding | IUCN data deficient | Good |
| Southern right whale (*Eubalaena australis*) | Coastal/Offshore | Migrant | Common | Migration | Nationally endangered; IUCN least concern | Good |
| Dusky dolphin (*Lagenorhynchus obscurus*) | Offshore/Coastal | | Common | Feeding | IUCN data deficient | Good |
| Common dolphin (Delphinus sp.) | Coastal | Resident | Rare | Feeding | IUCN least concern | Good |
| Minke whale (*Balaenoptera acutorostrata & B. bonaerensis*) | Offshore | Migrant | Rare | | IUCN data deficient | Poor |
| Sei whale (Balaenoptera borealis) | Offshore | Migrant | Rare | | IUCN endangered | Poor |
| Fin whale (Balaenoptera physalus) | Offshore | Migrant | Rare | | IUCN endangered | Poor |
| Risso's dolphin (*Grampus griseus*) | Offshore | | Rare | | IUCN least concern | Poor |
| False killer whale (*Pseudorca crassidens*) | Offshore | Migrant | Rare | | IUCN data deficient | Poor |
| Southern Right whale Dolphin (*Lissodelphis peronii*) | Offshore | | Rare | Feeding? | Not threatened; IUCN data deficient | Poor |
| Sperm whale (*Physeter macrocephalus*) | Offshore | Migrant | Rare | Feeding | Non-threatened; IUCN vulnerable | Moderate |
| Pygmy sperm whale (*Kogia breviceps*) | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Arnoux's Beaked whale (*Berardius arnuxii*) | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Bottlenose whale (*Hyperoodon planifrons*) | Offshore | | Rare | | IUCN least concern | Poor |

| | | | | | | |
|---|---|---|---|---|---|---|
| Andrews Beaked whale (*Mesoplodon bowdoini)* | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Gray's Beaked whale (*Mesoplodon grayi*) | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Strap-toothed Pygmy Sperm Whale (*Kogia breviceps*)<br>Beaked Whale (*Mesoplodon layardii)* | Offshore | | Rare | Feeding | Data deficient; IUCN data deficient | Poor |
| Shepherd's Beaked whale (*Tasmacetus shepherdi)* | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Cuvier's Beaked whale (Ziphius cavirostris) | Offshore | | Rare | Feeding | IUCN least concern | Poor |
| Hector's Beaked whale (Mesoplodon hectori) | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Pygmy Beaked whale (Mesoplodon peruvianus) | Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Hourglass dolphin (*Lagenorynchus cruciger*) | Offshore | | Rare | Feeding | IUCN least concern | Poor |
| Killer whale (Orcinus orca) | Coastal/Offshore | Migrant/Resident | Rare | Feeding | Nationally Critical; IUCN data deficient | Moderate |
| Pygmy right whale (*Caperea marginata*) | Coastal/Offshore | | Rare | Feeding | IUCN data deficient | Poor |
| Bottlenose dolphin (Tursiops truncates) | Coastal/Offshore | | Rare | Feeding | Nationally endangered/IUCN least concern | Moderate |
| Blainville's Beaked whale (*Mesoplodon densirostris)* | Offshore | | Vagrant | Feeding | IUCN data deficient | Poor |
| Striped dolphin (*Stenella coeruleoalba)* | Offshore | | Vagrant | Feeding | IUCN least concern | Poor |
| True's Beaked whale (*Mesoplodon mirus)* | Offshore | | Vagrant | Feeding | IUCN data deficient | Poor |
| Hector's dolphin (*Cephalorynchus hectori*) | Coastal | Resident | Vagrant | | Nationally endangered; IUCN endangered | Good |

#### *4.2.4.2 Migration paths through the Toroa Operational Area*

During spring, most of the baleen whales residing in the Southern Hemisphere migrate from the Pacific Islands down to the Antarctic Ocean to feed. They return back to the Pacific Islands during autumn-winter for the breeding season (May-July) (DOC, 2007). The distribution and migration paths around NZ for humpback, sperm, and southern right whales are shown in Figure 24 (Section 4.2.4.4). The northern migration routes back up to the Pacific Islands are relatively well known for some species, however the southwards routes are not. The Toroa 3D MSS is currently expected to start in February/March 2015, and take approximately 35 days; therefore it is considered that Toroa 3D MSS will be complete prior to the northward migrations and after the southern migrations of whales. However, if large numbers of migratory whales were believed to be within the Toroa Operational Area, DOC would be notified and additional mitigation measures would be discussed between DOC and WEL.


**Figure 24: Whale distribution and migration pathways in NZ waters**
(Te Ara, 2014d)

#### *4.2.4.3 Protected cetacean species in the Toroa Operational Area*

Eight species of marine mammal are included in the NZ threat classification list, either as "nationally critical", "nationally endangered" or "range restricted" (Table 9) (Baker *et al.*, 2010). Six of these species have been identified as potentially present within the Toroa Operational Area during the Toroa 3D MSS (killer whale, southern elephant seal, southern right whale, Hector's dolphin, NZ sea lion and bottlenose dolphin).

**Table 9: Marine mammals on NZ threat classification list (Baker *et al.*, 2010)**

| Marine Mammal Species | NZ Threat Classification | IUCN Classification | Summary | Distribution | Likely to be in Survey Area |
|---|---|---|---|---|---|
| Bryde's whale *(Balaenoptera edeni)* | Nationally critical | Data deficient | Generally a coastal species but does live in the open ocean.<br>Bryde's whales prefer temperate waters and are observed off the NZ coast generally north of the Bay of Plenty. This species of whale is believed to rarely venture beyond 40 degrees south. | Have a preference for warmer waters.<br>Is unlikely to occur in the Toroa Operational Area | × |
| Killer whale *(Orcinus orca)* | Nationally critical | Data deficient | Feeds on a variety of animals which include other marine mammals and fish species.<br>They are believed to breed throughout the year and appear to migrate based on the availability of prey. | Largely unknown but tend to travel according to the availability of food. Killer whales are widely found in all oceans of the world although more dominant in cooler waters.<br>Likely to occur in the Toroa Operational Area. | ✓ |
| Maui's dolphin *(Cephalorhynchus hectori maui)* | Nationally critical | Critically endangered | World's smallest dolphin and found in inshore waters on the west coast of the North Island.<br>Subspecies of Hector's dolphin. | Generally live close to shore (within 4 nautical miles) although the 100 m depth contour has been indicated as being their offshore distribution given current scientific understanding.<br>Only found on west coast of the North Island.<br>Is unlikely to occur in the Toroa Operational Area. | × |
| Southern elephant seal *(Mirounga leonina)* | Nationally critical | Least concern | They are the largest species of seal and feed on squid, cuttlefish and large fish.<br>Generally only comes ashore in spring/summer on offshore islands and some mainland areas to breed and moult; otherwise lives mostly at sea. They have an inflatable proboscis (snout) which is most present in adult males which is thought to increase the bull elephant seals roar. | Primary range includes the Antipodes, Campbell, Auckland, Snares Islands and the surrounding Southern Ocean. They are occasionally found on the mainland from Stewart Island to the Bay of Islands.<br>Could possibly be observed in the Toroa Operational Area. | ✓ |
| Southern right whale *(Eubalaena australis)* | Nationally endangered | Least concern | Present both offshore and inshore.<br>Are baleen whales with a diet consisting of krill and other zooplankton, particularly copepods.<br>Mate and calve during winter months in sheltered sub Antarctic harbours such as Auckland Islands and Campbell Island.<br>Often travel offshore during the feeding season; but they give birth in coastal areas (American Cetacean Society, 2010). | Likely to occur as a transient species in the Toroa Operational Area. | ✓ |
| Hector's dolphin *(Cephalorhynchus hectori)* | Nationally endangered | Decreasing | One of the smallest dolphin species (less than 1.5m long). Generally live inshore although have been sighted up to 20 Nm from the coast. | Patchily distributed around the South Island coast. On east coast live between Banks Peninsula and Te Waewae Bay and Porpoise Bay in the south. There are also populations around Kaikoura and Cloudy Bay/Marlborough Sounds.<br>Could possibly be observed in the Inshore section of the Toroa Operational Area. | ✓ |
| NZ sea lion *(Phocarctos hookeri)* | Nationally critical | Decreasing | Feeds on fish, invertebrates, and occasionally birds or other seals.<br>Breeding occurs in summer months with pupping occurring in December/January. Pups are weaned in July/August. | Known to forage along continental shelf breaks with primary range including the Auckland, Campbell, and Snares Islands.<br>Likely to be encountered in the Toroa Operational Area. | ✓ |
| Bottlenose dolphin *(Tursiops truncatus)* | Nationally endangered | Least concern | Are found worldwide in temperate and tropical waters, generally north of 45 degrees south. Population density appears to be higher near shore. Resident bottlenose dolphins are found off the east coast of the North Island, the northern tip of the South Island, and in Doubtful Sound. | Could possibly occur in the Toroa Operational Area. | ✓ |

#### *4.2.4.4 Ecological summaries of most commonly occurring cetacean species in the Toroa Operational Area*

##### *4.2.4.4.1 Blue Whale*

Two subspecies of blue whale occur in the waters of the South Pacific: the Antarctic blue whale (*Balaenoptera musculus intermedia*) and the pygmy blue whale (*Balaenoptera musculus brevicauda*). These two subspecies display differences in the length of their tail stock, length of their baleen and blowhole shape (Todd, 2014; Shirihai & Jarrett, 2006). In the field, they are difficult to distinguish and scientists often rely on acoustics or genetic sampling to confirm identification of animals to sub-species level (Samaran *et al.*, 2010; Attard *et al.*, 2012).

Blue whales hold the impressive title of the largest animals to ever live. Adults of the species can reach up to 33 m long and weigh up to 180 tonnes (Baker, 1999; Todd, 2014). This fact alone can aid identification of the species in the field. Additional distinguishing features include the species' large head, tiny dorsal fin which sits over three-quarters of the way down an elongated body, and columnar blow which is the tallest of the baleen whales, reaching up to 12 m in height (Shirihai & Jarrett, 2006).

Blue whales depend on krill (euphausiids) as their primary food source. They can be seen lunge feeding on krill surface swarms (generally at night) or diving to depths of up to 100 m for 10-20 minutes (although they are capable of diving to 500 m for 50 minutes) (Todd, 2014). Blue whales have the highest prey demands of any predator and can consume up to two tonnes per day (Rice, 1978; DOC, 2007). Large aggregations of food in upwelling areas are therefore of great importance to these whales.

Blue whales vocalise at a low frequency (average of 0.01 – 0.110 kHz but some calls have a precursor of 0.4 kHz) (McDonald *et al.*, 2001; Miller *et al.*, 2013) resulting in their vocalisations being able to travel hundreds of kilometres through the water. Blue whale calls can reach levels of up to 188 dB re 1ųPa $m^{-1}$ (Aroyan *et al.*, 2000; Cummings and Thompson, 1971).

The IUCN red list of threatened species currently lists the Antarctic blue whale as "critically endangered" and the pygmy blue whale as "data deficient". In contrast, the NZ threat classification system classifies blue whales "migrant" and therefore does not designate a threat status however blue whales are listed as a "Species of Concern" under the Code of Conduct. DOC have stated that the NZ threat classification for blue whales may change if further research demonstrates blue whales are resident or breeding in NZ waters. Despite blue whales being such large animals, they are fairly elusive and little is known about their distribution or habitat use patterns. Worldwide, aggregations of blue whales are known to occur in areas of upwelling which coincide with lower sea surface temperature relative to surrounding waters and high concentrations of euphausiids (Fiedler *et al.*, 1998; Burtenshaw *et al.*, 2004; Croll *et al.*, 2005; Gill *et al.*, 2011).

Torres (2013) published a paper on a previously unrecognised blue whale foraging ground in the South Taranaki Bight. Despite the difficulties in distinguishing the two blue whale sub-species in the field (as mentioned above), Torres suggested that the animals observed in the South Taranaki Bight are likely to be pygmy blue whales based on the timing of the sightings (summer) and on the widely accepted knowledge that pygmy blue whales will remain at lower latitudes during the austral summer (Torres, 2013).

There have been no recorded sightings of blue whales within the Toroa Operational Area, although there have been three sightings directly to the north from previous MSSs and two in Foveaux Strait. However, it is considered that blue whales could be observed within the Toroa Operational Area.

In contrast to sightings in the field, strandings generally enable the identification down to sub-species level. There are no records of stranded blue whales on the DOC stranding database in the Southland region.

#### *4.2.4.4.2 Humpback Whale*

Humpback whales are a baleen whale belonging to the rorqual family. They have a broad head which presents a rounded but slim profile. Their overall body shape is curved. They have unusually long pectoral fins and flukes with serrated edges and white undersides. The top of the humpback's head and lower jaw have bump-like knobs called tubercules. Each tubercule has at least one stiff hair which is believed to help detect movement in nearby waters.

The humpback whale feeds on small fish or krill during dives which generally only last 15 minutes but can reach 40 minutes (Shirihai and Jarrett, 2006). During periods of feeding, humpback whales can consume up to two tonnes of krill per day Two notable feeding techniques which have been observed in this species are lunge-feeding, where the whale thrusts forward with its mouth open in order to capture prey, and bubble-netting, where the whale dives downwards in a spiral around its prey while producing bubbles which will act as a net to concentrate the shoal (Shirihai and Jarrett, 2006).

Both male and female humpback whales produce communication calls, but only males emit the long, loud, complex 'songs' which consist of several sounds in a low register, varying in amplitude and frequency, and typically lasting from 10 to 20 minutes (American Cetacean Society, 2014). In addition to vocalisations, "social sounds" in humpback whales are known to include sounds generated from surface activity such as body slaps, flippering and tail-lobbing.

Whaling in the southern hemisphere reduced the population from ~120,000 animals to 15,000 but the population is now currently recovering (Suisted & Neale, 2004) and the IUCN lists the status humpback whale populations worldwide as "least concern".

Although there have been no observations of humpback whales within the Toroa Operational Area, a number of sightings have occurred throughout the Southland region, mostly during autumn and winter months. It is considered the lack of sightings within the Toroa Operational Area is more of indication of the lack of observer effort in the area as opposed to an absence of this species. Strandings of humpback whales have also occurred on Stewart Island and the south coast of the South Island. Although during the acquisition of the Toroa 3D MSS most of the humpback whales will be down in Antarctic waters feeding; it remains possible that a humpback whale could be observed.

As mentioned in Section 4.2.4.2, humpback whales are a migratory species, undertaking one of the longest migrations of any animal (Todd, 2014). During summer months, humpbacks feed in Antarctic waters for 80 – 100 days, consuming up to two tonnes of krill per day. In winter, they migrate north to tropical or sub-tropical waters (i.e. Tonga) for mating and calving. During this time, the humpback whales fast and live off their fat reserves accrued throughout the summer and as a result can be seen swimming at the surface or executing shallow dives.

Their annual northern migration sees them travel up the east coast of the South Island and then either along the east coast of the North Island, or through the Cook Strait and up the west coast of the North Island on the way to the tropics and their winter breeding grounds (Dawbin, 1956; Shirihai, 2002). DOC undertake whale monitoring in the Cook Strait each year during June and July to coincide with the northern migration of the humpback whales to the South Pacific breeding grounds.

The southern migration back to the feeding grounds takes place along the west coast of the South Island and is led by the lactating females and yearlings who are followed by the immature whales, and lastly the mature males and females. The pregnant females are last to migrate south in late spring (Gibbs & Childerhouse, 2000).

#### *4.2.4.4.3 Pilot Whale*

There are two species of pilot whale: long-finned and short-finned. Of these, the long-finned pilot whale is most likely to occur in NZ waters.

Long-finned pilot whales are a toothed whale. Males are larger than females and can grow up to 6 m long and weigh 3 tonnes. They are black or greyish-brown in colour, have a low, falcate dorsal fin which is centrally placed along their back, and no distinguishable beak.

Long-finned pilot whale feed on fish and squid in deep water along shelf breaks. A study of stomach contents of stranded pilot whales along the NZ coastline has indicated that this species preys predominantly on cephalopods, mainly arrow squid and common octopus (Beatson *et al.*, 2007). The same study identified a significant proportion of the squid and octopus individuals found in stomach contents as juveniles. Based on this information, a conclusion could be drawn that the majority of feeding events had taken place in waters shallower than 500 m (based on the distribution of juvenile stages of the prey species). However, this should information treated with caution given the small sample size used the study (n=5) and the inherent biases of strandings data. Furthermore, other studies outside of NZ waters have documented this species performing deep foraging dives (Baird *et al.*, 2002; Heide-Jorgensen *et al.*, 2002). Importantly, all of these depth ranges coincide with those found inside the Toroa Operational Area.

Long-finned pilot whales are listed as data deficient by the IUCN (IUCN red list).

Pilot whales are notorious for stranding along the NZ coastline. Strandings generally peak in spring and summer (O'Callaghan, 2001), with Farewell Spit renowned for the number of whale strandings each year. They are very social animals and often travel in groups of over 100 individuals and it was originally thought that the family relationships among the pilot whales was the cause of strandings. The theory was that if one or more whales stranded due to sickness or disorientation, a chain reaction was triggered which drew the healthy whales into the shallows to support their family members (Oremus *et al.*, 2013). However, from genetic data gathered from stranded whales in NZ and Tasmania, it has been proved that stranded groups are not necessarily members of one extended family and many stranded calves were found with no mother present (Oremus *et al.*, 2013).

Additionally to these stranding records, pilot whales have been observed within and surrounding the Toroa Operational Area from the DOC sighting database. During MSSs conducted previously a number of pilot whales were observed to the northeast of the Toroa Operational Area. Therefore, it is highly likely that pilot whales will be observed during the Toroa 3D MSS.

#### *4.2.4.4.4 Southern Right Whale*

Southern right whales can reach between 15 – 18 m in length. Distinguishing features of this species include callosities on the upper jaw and facial area of the animal (often white in colour due to infestations of whale lice, parasitic worms and barnacles), and the absence of dorsal fin. They are a slow moving whale, often swimming at speeds less than 9 km/hour, making them vulnerable to ship-strikes and in the past, whaling.

Right whales feed predominantly on zooplankton and tend to 'skim feed' which involves swimming through swarms of prey with the mouth wide open. This is done either at the surface or at depth (Braham and Rice).

Right whales produce a range of different vocalisations. In NZ waters, a majority of 'upcalls' are recorded and on average vocalisations have frequencies of below 1 kHz (Webster and Dawson, 2014). There have been no sightings of southern right whales within the Toroa Operational Area. With the Toroa 3D MSS scheduled for the summer period it is unlikely that a southern right whale would be observed as they are likely to be feeding down in Antarctic waters.

Southern right whales are regarded as nationally endangered but recent data indicate that they are making a recovery. The population was heavily reduced by whaling which caused numbers to drop from ~17,000 to ~1,000 (Carroll *et al.*, 2011; Suisted and Neale, 2004). Given this massive decline in southern right whale stocks, DOC prioritised the collection of sighting data and genetic samples for this species. Resulting genetic evidence suggests that southern right whales seen around mainland NZ and the NZ subantarctic are part of a single stock (Carroll *et al.*, 2011) and it is thought that this single NZ population range between two wintering grounds: the primary wintering ground in the NZ subantarctic and secondary wintering ground of mainland NZ (Carroll *et al.*, 2011). Rayment & Childerhouse (2011) estimated the population of southern right whales in the subantarctic using annual photo-ID surveys from 2006-2011. The survey resulted in 511 individuals being identified and subsequent modelling estimated that 1,286 (689-2,402) frequented the survey area.

Worldwide, southern right whales are regarded as of "least concern" (IUCN red list).

There have been a number of sightings of southern right whales in the waters surrounding the Toroa Operational Area, although most sightings have occurred close to shore. There have been some offshore sightings of the southern right whales also and during summer months. As a result there is the potential that a southern right whale could be observed during the Toroa 3D MSS.

Southern right whales are the only baleen whale to breed in NZ waters; during winter months calving occurs in coastal waters whereas in summer they migrate to the Southern Ocean (sub-Antarctic and Campbell Islands) to feed. Their northern migration sees them go through the Cook Strait between May-October, although sightings have been recorded outside of this period (see Section 4.2.4.2).

#### *4.2.4.4.5 Dusky dolphin*

The dusky dolphin is a compact medium-sized dolphin which can measure up to 2.2 m in length. It has a tall, sickle-shaped fin and distinctive markings on its flank and head. A bluish-black colour covers the dorsal area from its rostrum to its tailstock; while the ventral side of the animal is white and a white blaze extends from its tail stock and branches into grey stripes by its dorsal fin. Another distinctive feature of this animal is sloping forehead and almost indistinctive beak (Shirihai & Jarrett, 2006).

As in other dolphin species, dusky dolphins are known to prey upon a range fish and squid species. Wursig *et al.* (2007) indicated that, overall, target prey species can vary seasonally. However, species that are present year round in the diet of dusky dolphin include lanternfish, hoki and arrow squid (Wursig *et al.*, 2007). Furthermore, an onshore/offshore pattern was detected in the Kaikoura population, with animals ranging further offshore at night to feed in deeper waters on fish, crustaceans and cephalopods (Shirihai and Jarrett, 2006; Wursig *et al.*, 2007). Notably, dusky dolphins are also known to associate with a number of other species and even to feed cooperatively with animals such as fur seals (DOC, 2014b).

The dusky dolphin produces bi-modal echolocation signals, with a low frequency peak at 40-50 kHz and a high frequency peak at 80 to 110 kHz. These frequencies are amongst the highest recorded in the field for dolphins (Au and Wursig, 2004).

The dusky dolphin is listed as "data deficient" in by the IUCN red list.

The dusky dolphin is found exclusively in the southern hemisphere and is known to associate with inshore areas and shallow shelves (Wursig *et al.*, 2007). In NZ, the species can be found in coastal areas of both Islands, with larger populations south of East Cape, in the Marlborough Sounds and off Kaikoura (Hawke, 1989; Wursig *et al.*, 2007). Dusky dolphins also infrequently extend their range as far south as the Banks Peninsula and north coast of Otago (DOC, 2014b; Wursig *et al.*, 2007). A large number of dusky dolphins have been observed in the southern waters both within and surrounding the Toroa Operational Area. As a result it is highly likely that dusky dolphins will be observed during the Toroa 3D MSS.

Dusky dolphins can be found in groups of 6-20 animals up to several hundred individuals (Shirihai and Jarrett, 2006; Wursig *et al.*, 2007). It has been proposed that group size will vary depending on the activity (resting in small groups, feeding/travelling in larger groups), location (onshore/offshore), and risk of predation (strength in number for protection against killer whales). Dusky dolphins groups including calves were most frequently recorded in the summer in waters around Kaikoura (Wursig *et al.*, 2007). More widely, calving is known to occur between December and mid-January (DOC, 2014b).

#### *4.2.4.4.6 Short-beaked Common Dolphin*

The common dolphin has a distinctive colouring of purplish-black to dark grey on top to white and creamy tan on the underside. They have a sickle-shaped dorsal fin and a slender, pronounced beak. They can grow to 1.7 – 2.4 m in length, weigh 70 – 110 kg.

Common dolphins feed on a variety of prey which are generally under 10 cm in length. A recent study determined jack mackerel, anchovy and arrow squid as the predominant prey species for common dolphins in NZ (Meynier *et al.*, 2008). Importantly, both jack mackerel and arrow squid can be found inside the Toroa Operational Area. Common dolphins are known to either feed alone or cooperatively and a number of different feeding techniques can be employed. In NZ waters, cooperative techniques such as line abreast (where the dolphins line up and drive the prey in front of them), carouselling (where the prey are trapped against the surface thus creating a 'bait ball'), wall formation (where dolphins will drive the prey towards another group of dolphins) and bubble blowing (where bubbles are produced by the dolphins in order to stun the prey), and individual strategies such as and high speed pursuit, kerplunking (where the dolphin slaps its fluke against the surface of the water to create a noise) and fish-whacking (where the dolphin strikes the prey using its fluke) have been observed (Neumann, 2001).

As in most delphinid species, common dolphins are known to produce whistles, echolocation click trains and burst pulse calls. Echolocation click trains are involved in locating prey and navigation whereas burst pulse calls and whistles are a form of communication. Petrella *et al.* (2012) determined the whistle characteristics for common dolphins in the Hauraki Gulf. This study indicated that the average frequency and length of whistles are respectively 10-14kHz and 0.27 seconds.

The common dolphin status is listed as "least concern" in the IUCN red list.

Common dolphins are distributed around the entire NZ coastline, generally remaining within a few kilometres of the coast. They are social animals and often form groups of several thousand individuals. In the Bay of Islands, the mean water depth of sightings is 80 m, but ranges from 6 – 141 m (Constantine & Baker, 1997). In addition, results from the study of stomach contents of common dolphins in NZ waters have given indications of an onshore-offshore diel migration in this species (Meynier *et al.*, 2008). With a minimum depth of 750 m the Toroa Operational Area is deemed to be outside of the core range of this species however, the DOC sighting database has records of common dolphins within and surrounding the Toroa Operational Area. Therefore, it is likely that common dolphins will be observed during the Toroa 3D MSS.

#### *4.2.4.4.7 Minke Whale*

Worldwide, there are two species of minke whale and one sub-species: the northern minke (*Balaenoptera acutorostrata*) (confined to northern hemisphere), the Antarctic or southern minke (*Balaenoptera bonaerensis*) (confined to the southern hemisphere including NZ waters) and a sub-species, the dwarf minke (*Balaenoptera acutorostrata*) (present in NZ waters).

The minke whale is a small rorqual measuring up to 10 m in length. It has a sickle-shaped dorsal fin situated two-thirds of the way down its back. The rostrum is triangular and has a single central ridge. Northern and dwarf minkes present pectoral fins which have a marked white band across the upper side. This feature is only clearly seen when the animal breaches or in very clear water (Shirihai & Jarrett, 2006).

Minke whales feed on krill, crustaceans and small fish. They will perform dives which last on average between 3-9 min (maximum 20 min). Antarctic minkes are known to feed in Antarctic feeding grounds during the austral summer and are scarce in NZ and Tasmanian waters. Records of dwarf minkes are limited and suggest a circumpolar distribution in the Antarctic with additional areas of occurrence around 7° S in the Atlantic and 11° S in the Pacific.

The minke whale produces low frequency pulse trains. The overall frequency range of these vocalisations is 100-500 Hz but the main energy is focussed between 80Hz and 140 Hz. These sounds are used for communicating over large distances.

Antarctic minke whale has a "data deficient" population status worldwide according to the IUCN red list. As a result, any sightings of this species at sea collected during the Toroa 3D MSS will contribute to the knowledge of this species.

There has been one recorded sighting of a minke whale on the DOC sighting database and that was during winter months and it was observed 22 km southeast of Pegasus Bay, Stewart Island. One stranding of a minke whale has been recorded at Masons Bay on the west coast of Stewart Island. It is considered that there is the potential for a minke whale to be observed during the Toroa 3D MSS.

#### *4.2.4.4.8 Sei Whale*

On average, sei whales have a body length which ranges between 15 – 18 m and a weight of 20 – 25 tonnes. They have a V-shaped head and an erect dorsal fin situated two-thirds of the way along their back. This rorqual's dive pattern at the surface is distinctive as the dorsal fin is visible almost simultaneously to the blow (Shirihai & Jarrett, 2006).

Sei whales feed mostly on copepod species in Antarctic waters. In the absence of copepods, they may also prey upon euphausiid swarms (Mizroch *et al.*, 1984a). This species of whale is known to feed at dawn and can be seen to turn on its side while feeding (Shirihai and Jarrett, 2006).

The acoustics of sei whales are not well studied and there are indications of geographic variations in frequency and nature of the calls. Vocalisations from this species recorded in Antarctic waters included low frequency tonal calls (0.45 ± 0.3 s long and 0.433 ± 0.192 kHz in frequency), frequency swept call and broadband 'growls' or 'wooshes'.

The IUCN red list classifies the sei whale as "endangered".

Sei whales are among the fastest swimming cetaceans. Swimming speeds of up to 50 km/hour have been recorded enabling animals to travel up to 4,320 km in ten days. During February-March, southern hemisphere sei whales migrate south to subantarctic waters where there is an abundance of food. Unlike other rorquals, their distribution does not extend to the ice edge (Mizroch *et al.*, 1984a). In the winter months, they return to the waters between the South Island of NZ and Chatham Islands to calve. Sei whales have been recorded on the DOC sighting database both within and surrounding the Toroa Operational Area during summer and autumn months. Therefore, it is likely that sei whales could be encountered during the Toroa 3D MSS.

#### *4.2.4.4.9 Fin whale*

The fin whale is the second largest marine mammal, second only to the blue whale, reaching up to 27 m in length (Mizroch *et al.*, 1984b; Shirihai & Jarrett, 2006). This species presents a small backwards swept dorsal fin two-thirds of the way down its back; a "V" shaped head with a longitudinal ridge and asymmetric pale coloration on its right jaw; and variable pale chevrons from flipper to shoulder (Shirihai & Jarrett, 2006).

The fin whale's diet is known to vary locally and seasonally. Target species range from fish and squid to krill and other crustaceans (Mizroch *et al.*, 1984b; Shirihai and Jarrett, 2006). Feeding techniques include lunging and gulping which can sometimes be observed at the surface. This species also has the peculiarity of often feeding on its right side.

The fin whale uses sound to communicate over large distances. These calls are thought to be important for feeding and mating. They have been described as short (<1 second) down-swept tones ranging from 28 to 25 Hz (Širović *et al.*, 2004) at source levels of 189+/- 4dB re 1ɥPa $m^{-1}$.

Fin whales are listed by the IUCN red list as "endangered".

Similarly to other austral balaenoptera species, the fin whale can be found in warmer, lower latitudes in the winter, where the species breeds; and in the cooler waters of the Antarctic during the summer months, where the species feeds on krill and other small crustaceans. Although breeding grounds and migration paths are not well documented for this species, they are generally observed in deep offshore waters and are known to occasionally occur in NZ waters.

The DOC sighting database shows one recorded observation of a fin whale south of Nugget Point along the Catlins coast approximately 120 km to the north of the Toroa Operational Area. However, in a recent MSS southeast of Dunedin there were a number fin whales observed, therefore it is likely that a fin whale could be observed during the Toroa 3D MSS.

##### *4.2.4.4.10 Sperm Whale*

Sperm whales are globally distributed and are the largest of the toothed whales. Males can reach 18 m in length and weigh up to 51 tonnes; whereas females are usually half the weight and two-thirds the length.

Squid is their most common prey but they are also known to eat demersal fish (Torres, 2012). Sperm whales are odontocetes (toothed whales). Worldwide, squid is known to be a major component of this species' diet and is caught during deep foraging dives which can last over an hour (Evans and Hindell, 2004; Gaskin and Cawthorn, 1967; Gomez-Villota, 2007). During these dives, the sperm whales can reach depths of 3,000 m where no light can penetrate. This is where the whales become entirely reliant on sound to locate their prey and navigate. To do so, these animals produce echolocation clicks which are believed to enable them to determine the size, direction and distance of prey (Ocean Research Group, 2014). In addition, sperm whales also use clicks as a means of communication, to identify members of a group and coordinate foraging activities (Andre and Kamminga, 2000). All of these sounds will allow any sperm whales in the proximity to the *Polar Duke* to be heard on the PAM system onboard.

Under the IUCN classification system, sperm whales are currently listed as "vulnerable" whereas they are classified as "non-threatened" by the NZ classification system.

Although all whales have significant cultural importance in NZ, sperm whales in particular are regarded as chiefly figures of the ocean realm and are commonly recognised as taonga (treasure) to all Māori.

There have been a number of sperm whale sightings in the surrounding waters of the Toroa Operational Area from the DOC sighting database. A large number of the whales observed have also been during the summer months. Therefore it is considered that sperm whales could be observed during the Toroa 3D MSS.

#### *4.2.4.4.11 Pygmy Sperm Whale*

Pygmy sperm whales (*Kogia breviceps*) can grow up to 3.5 m in length and weigh 400 kg. They have no teeth in their upper jaw, only sockets, which the 10 – 16 pairs of teeth in the lower jaw fit into. They are discreet at sea. They lack a visible blow and have a low profile in the water. This makes them difficult to observe at sea unless weather conditions are calm with little or no swell.

Prey species for the pygmy sperm whales include cephalopods, fish and occasionally crustacean species (Shirihai and Jarrett, 2006).

Little is known of the acoustics of this species. However, data collected from live stranded animals has indicated the existence of two types of vocalisations: high frequency clicks which range from 500 Hz to 12 kHz and 'grunts' of approximately 3 kHz.

Given the lack in data available on this species, they are classified as "data deficient" by the IUCN red list.

There have been no recorded sightings of pygmy sperm whales in the Great South Basin. These stranding events have provided most of the available information for this species in the northwest of New Zealand.

It is assumed that pygmy sperm whales may be present in the Toroa Operational Area, but could be difficult to observe in most sea conditions.

#### *4.2.4.4.12 Beaked Whale*

Due to the limited sightings at sea, very little is known about the distribution of beaked whales within the NZ EEZ. Eleven species of beaked whales are present in NZ, however it is difficult to identify specific habitat types and behaviour for each individual species, as most of the information comes from stranded whales, and in some cases provides the only knowledge that they exist within NZ waters. Beaked whales are mostly found in small groups in cool, temperate waters with a preference for deep ocean waters or continental slope habitats at depths down to 3,000 m.

Based on these habitat preferences, it is surmised that some or all of the following species of beaked whale could occur within the Toroa Operational Area: Arnoux's beaked whale, southern bottlenose whale, Andrew's beaked whale, Hector's beaked whale, Blainville's beaked whale, Gray's beaked whale, strap-toothed beaked whale, pygmy beaked whale, True's beaked whale, Shepherd's beaked whale, Cuvier's beaked whale. However, it is known that these beaked whales will be difficult to observe at sea. The DOC stranding database has records for most of these species along the South Island coastline.

Beaked whales have been observed off the Dunedin coastline and in offshore waters off Oamaru.

#### *4.2.4.4.13 Killer Whale*

Killer whales are the largest member of the dolphin family; males can grow to 6 – 8 m and weigh in excess of six tonnes. They have an erect dorsal fin (taller in the male of the species) and the dorsal side of the animals is black with a distinctive oval white patch behind the eye and a grey "saddlepatch" behind the dorsal fin. It is believed that two populations exist within NZ waters; one inshore and one offshore although this is still not verified.

Worldwide, prey species vary from one ecotype to another with some forms of killer whale feeding on mammals and others on fish. As with all predatory species, the distribution of prey affects the distribution of killer whales and in NZ waters, they are more often found inshore during the NZ fur seal breeding season (November to January). This species is also known to feed on elasmobranchs in NZ waters.

Killer whales are known to echolocate and to produce tonal sounds (whistles). The whistles of wild killer whales have been noted to possess an average dominant frequency of 8.3 kHz and to generally last 1.8 s (Thomsen and Franck, 2001). Variations of these whistles (described as dialects) have been documented between pods (Deecke *et al.*, 2000). In addition, the use of echolocation has also been demonstrated to vary between orca groups, depending on the target prey species of a particular group (Barrett-Lennard *et al.*, 1996).

The resident NZ killer whale population is small (mean = 119 ± 24 SE) with broad distribution patterns around both North and South Islands (Visser, 2000). Within the NZ threat classification list killer whales are classified as 'nationally critical' (Suisted and Neale, 2004) whereas worldwide, they are classified as "data deficient" by the IUCN.

On 12 February 2014, nine killer whales stranded at Blue Cliffs Beach, near Tuatapere (South Coast of NZ) this was NZ's third largest stranding of killer whales and possibly one of the 10 largest internationally.

Killer whales have been observed to the southwest of the Toroa Operational Area and have been observed around the coastal waters of the southern part of the South Island. Therefore, it is considered that there is the potential for killer whales to be observed during the Toroa 3D MSS.

#### *4.2.4.4.14 Bottlenose Dolphin*

Bottlenose dolphins range from 2.4 – 4 m in length and 250 - 650 kg in weight. They have a tall, falcate dorsal fin situated centrally along their back and a distinctive stubby beak and robust forehead (Shirihai & Jarrett, 2006). Throughout the world, bottlenose dolphins are widely distributed in cold temperate and tropical seas, with NZ being the southernmost point of their range.

Bottlenose dolphins will feed on fish, krill and crustaceans and are known to feed cooperatively (Shirihai and Jarrett, 2006).

As members of the odontocete family, bottlenose dolphins produce two varieties of sound: 'clicks' which are used for echolocation purposes (0.8-24 kHz) and 'whistles' which are used as a form of communication (40-130 kHz).

This species is now listed as "Nationally Endangered" on the NZ threat classification list, largely due to their low abundance and concerns over potential decline in populations. Internationally, the species is classified as "least concern" by the IUCN red list. However, the Fiordland sub-population is listed as "critically endangered" by the IUCN.

Within NZ, there are three main coastal populations of bottlenose dolphins; approximately 450 live along the northeast coast of Northland, 60 live in Fiordland and there is a population living in the coastal waters between the Marlborough Sounds and the West Coast. The three populations each have differences within their DNA indicating little or no gene flow between the populations (Baker *et al.*, 2010). A sub-population of offshore bottlenose dolphins also exists that travels more widely and often in larger groups.

Most of the bottlenose dolphins observed in the southland region are around Foveaux Strait and Fiordland, although there is one recorded sighting to the northeast of the Toroa Operational Area. As a result there is the potential for a bottlenose to be observed during the Toroa 3D MSS; however, given the distance offshore it would most likely belong to the offshore sub-population.

#### *4.2.4.4.15 Hector's Dolphin*

Hector's dolphins are endemic to NZ waters and at 1.2 – 1.5 m in length they are one of the smallest cetaceans in the world. They have a highly distinguishable rounded dorsal fin and blunt snout. Their markings include a black mask which extends over the rostrum over to the pectoral fins.

Hector's dolphins forage on a range of small fish and crustacean species. Echolocation is used during foraging dives in order to locate prey.

Hector's dolphin use echolocation clicks (including 'cries' or 'squeals') to locate prey and to communicate. These vocalisations are centred around frequencies of 120-125 kHz (Dawson, 1990).

Over the last 40 years, their numbers have declined significantly and as a result, the species is classified as 'nationally endangered' by the NZ threat classification list and as 'endangered' on the IUCN red list. It is believed set nets are responsible for ~75% of the known Hector's dolphin's deaths but many more deaths may go unreported (MPI, 2014e; Project Jonah, 2014).

Hector's dolphins have a patchy distribution, generally living in three geographically distinct groups around the South Island. The most frequently sighted Hector's dolphins are found on the west coast between Jackson Bay and Kahurangi Point, on the east coast between Marlborough Sounds and Otago Peninsula, and on the south coast between Toetoes Bay and Porpoise Bay as well as in Te Waewae Bay (Fisheries Management Science Team, 2013). Smaller population densities are also found in Fiordland, Golden Bay and south Otago coast. There is significant genetic differentiation among the west, east and south coast populations, with little or no gene flow connecting them (Hamner *et al.*, 2012).

In recent years, MPI funded survey programmes have been conducted to assess abundance and distribution of the south coast South Island and east coast South Island populations of Hector's dolphin (Clement *et al.*, 2011; MacKenzie & Clement, 2013). The data collection programme involved summer and winter aerial surveys during which Hector's dolphins observed along transect lines were recorded. The resulting sightings data was analysed using mark-recapture and density surface modelling techniques to yield estimates of density and total abundance. It was estimated that the south coast South Island population includes 628 dolphins (95% CI = 301-1,311).

For the east coast South Island surveys, a total of 354 dolphin groups were sighted in summer and 328 dolphin groups were sighted in winter. After analysis, the data yielded estimates of 9,130 animals (95% CI = 6,342-13,144) for summer and 7,465 animals (95% CI = 5,224-10,641) for winter. Hector's dolphin numbers are believed to have increased within the Banks Peninsula MMS and are now routinely reported around the Marlborough Sounds (Hamner *et al.*, 2012). The South Island west coast population is estimated at about 5,400 (MPI, 2014e).

Hector's dolphins are often observed close to shore in waters of under 100 m depth as they prefer shallow, turbid environment. However, occasional sightings have occurred beyond the 100 m isobaths at distances out to 20 Nm off Banks Peninsula (MacKenzie & Clement, 2013).

The DOC sighting database has a number of records along the south coast of the South Island and off the Dunedin peninsula, all of which are in shallow coastal waters.

It is considered unlikely that a Hector's dolphin would be observed within the Toroa Operational Area, although they could be observed in shallower water when the seismic vessel is mobilising to and from the Toroa Operational Area and during port calls.

### 4.2.5 Pinnipeds

Nine species of pinnipeds (seals and sea lions) have been recorded in NZ waters (Suisted & Neale, 2004). Two of these are known to breed on the coastline adjacent to the Toroa Operational Area: NZ fur seal, NZ sea lion. An additional two species of pinniped are mentioned in the sections below: southern elephant seal and leopard seal. These are both Antarctic species which have been known to occasionally haul out on the coastline adjacent to the Toroa Operational area and therefore there is a small chance that they could be encountered during the Toroa 3D MSS.

#### *4.2.5.1 NZ fur seal*

Within NZ waters, the NZ fur seal (*Arctocephalus forsteri*) is the most commonly occurring pinniped. They are distributed around both islands, with a conservative population estimate of 50,000 – 60,000.

NZ fur seals forage for food along continental shelf breaks up to 200 km offshore but are generally distributed inshore, in water depths of less than 100 m. They are known to dive for up to 12 minutes (~ 200 m) to feed on fish (small mid-water fish, conger eels, barracouta, jack mackerel and hoki), squid and octopus.

Breeding season in NZ fur seals extends from mid-November to mid-January and pups are suckled for up to 300 days. During that time, females will alternate between foraging at sea and returning to the rookery to feed their young.

As mentioned above, NZ fur seals are present around the entire NZ coast with sighting information covering the extent of the country, although these sightings are largely centred in the southern waters around the Toroa Operational Area. It is noted that a large proportion of the sighting observations have arisen from previous MSS around NZ where dedicated MMOs have been onboard. As a result, it is highly likely that NZ fur seals will be observed within the Toroa Operational Area.

#### *4.2.5.2 NZ Sea Lion*

The NZ sea lion is one of the rarest pinnipeds in the world. Whereas in the past this species would have inhabited the entire NZ coastline (Childerhouse & Gales, 1998), breeding colonies can now only be found on Auckland Islands (accounting for 86% of births) (Chilvers *et al.*, 2007), Campbell Islands, and the Otago Peninsula (the descendants of a single female which started to breed there in 1993) (McConkey *et al.*, 2002).

Overall, NZ sea lions prey on a variety of different species including fish, rays, cephalopods, and crustaceans. The species has even been observed to prey upon birds and other pinniped species. However, in the Auckland Island population, two well defined dive profiles have been documented which split the population in "benthic divers" and "meso-pelagic divers". Each group relies on different feeding grounds inside the Auckland Island shelf, with benthic divers travelling greater distances from the breeding site and spending more time at sea in order to feed (Chilvers & Wilkinson, 2009). Another study considered the foraging patterns of lactating females of the species on the Otago peninsula and found that they present significantly smaller foraging ranges than the subantarctic individuals and overall are diving less deep than their Auckland Island counterparts (Augé *et al.*, 2011).

Breeding occurs during the summer months (December and January) during which time both males and females of the species will assemble in rookeries (breeding sites). Outside of this period, the NZ sea lion can be observed at sea either diving for up to 11 minutes or "porpoising" across the surface of the water (Shirihai & Jarrett, 2006).

There have only been two recorded sightings of the NZ sea lion on the DOC sighting database (current as at February 2014), one at Stewart Island and one at the Otago Peninsula. However, this database does not include fisheries observer sightings which is likely to increase this number of sightings from two, therefore it is considered there is the potential for a NZ sea lion to be observed during the Toroa 3D MSS.

The NZ government has classified the NZ sea lion as nationally critical and it is also listed as "vulnerable" in the IUCN red list.

#### *4.2.5.3 Southern Elephant Seal*

The southern elephant seal is the largest species of seal in the world, with adult males reaching 3,500 kg. The species range covers the Southern Ocean and most islands of the subantarctic. The NZ population congregates in breeding colonies on the Antipodes Islands and on Campbell Island between May and November, and during the winter months, these animals will frequently visit the Auckland and Snare Islands. Occasionally, they have been observed off Stewart Island and the Otago coastline (DOC, 2014c).

Elephant seals feed mainly on deepwater fish and cephalopods which they catch during deep dives which last up to 20 minutes. Rest intervals between dives are typically short, resulting in these animals being elusive at sea (Shirihai & Jarrett, 2006).

The southern elephant seal is classified as "least concern" by the IUCN red list; however, there has been a 5-11% decline in animals at breeding colonies over the past few years. This species is classified as "nationally critical" in NZ.

There is only one sighting on the DOC sighting database that is close to the Toroa Operational Area, and that is approximately 120 km to the northeast. However, it is considered that there is the potential for a southern elephant seal to be observed during the Toroa 3D MSS.

#### *4.2.5.4 Leopard Seal*

The leopard seal is a dark blue-grey Antarctic seal which can reach up to 3.8 m in length. It is renowned for its powerful jaws and almost reptilian profile. It is a generally solitary species and feeds on krill, fish, penguins and the young of other seal species.

Leopard seals breed between November and January on the Antarctic pack ice and lactation is thought to last one month.

Distribution of this species is concentrated around the Antarctic but there are frequent reports of visits of this species to the subantarctic Islands and NZ shoreline.

There has been one recorded sighting of a leopard seal within the Toroa Operational Area and one in close proximity to the northeast. Both of these sightings were in March so there is the potential that a leopard seal could be observed during the Toroa 3D MSS.

The leopard seal is listed as "least concern" by the IUCN red list.

### 4.2.6 Marine Reptiles

Seven marine reptile species are known to occur in NZ waters: leatherback turtle (*Dermochelys coriacea*) (60 records), green turtle (*Chelonia mydas)* (44 records), yellow-bellied sea snake (*Pelamis platurus)* (21 records), hawksbill turtle (*Eretmochelys imbricate)* (18 records), the loggerhead turtle (*Caretta caretta)* (18 records), olive Ridley turtle (*Lepidochelys olivacea)* (four records), and the banded sea snake (*Laticauda colubrine)* (two records). These species are most commonly found in warm waters (DOC, 2014d).

Live or dead specimens or shed skins of only three of these species have been documented within or in the vicinity of the Toroa Operational Area (DOC, 2014d). These species previously observed are the leatherback turtle, loggerhead turtle, and olive ridley turtle. Although most of these records are coastal, this distribution is probably an indication of higher numbers of potential observers in these areas rather than an accurate representation of the animals' distribution in NZ waters. As a result, these reptiles may well be observed within the Toroa Operational Area, in which case the sightings will be recorded and in order to increase the knowledge of NZ's marine reptiles. However, it should be noted that Taranaki is outside of the core range of these species and any individuals observed in Southland waters would be considered to be vagrant.

### 4.2.7 Seabirds

There are 86 species of seabirds which breed in NZ waters. These include albatross, cormorants, shags, fulmars, petrels, prions, shearwaters, terns, gulls, penguins and skuas (Farr Biswell, 2007).

Worldwide, seabirds are more threatened than any other comparable bird groups (28% are threatened globally). Furthermore, pelagic seabirds are at higher risk than coastal birds as a result of their comparatively small clutch size (Croxall *et al.*, 2012).

According to a report published by Bird Conservation International, NZ has the highest number of "seabird species of conservation concern (breeding and non-breeding species combined)" (Croxall *et al.*, 2012).

A number of sources (Parkinson, 2006; Robertson *et al.*, 2013; IUCN, 2014; MPI, 2014f; NZ Birds online, 2014b) have been used to identify the seabirds most likely to be observed in and around the Toroa Operational Area and their conservation status. The list is as follows:

- **Snowy wandering albatross** *(Diomedea exulans)* – common visitor to NZ waters; vessel follower; IUCN "vulnerable" status; DOC conservation status "non-resident native, migrant, threatened overseas";
- **Gibson's wandering albatross** *(Diomedea gibsoni)* – uncommon endemic; vessel follower; not yet assessed by IUCN; Toroa Operational Area within "species normal range"; DOC conservation status "threatened, island endemic, one location";
- **Antipodean wandering albatross** *(Diomedea antipodensis)* – uncommon endemic; vessel follower; IUCN "vulnerable" status; Toroa Operational Area within "species normal range"; DOC conservation status "threatened, nationally critical island endemic, recruitment failure, range restricted";
- **Southern royal albatross** *(Diomedea epomophora)* – locally common endemic; IUCN "vulnerable" status; Toroa Operational Area within "species full range"; DOC conservation status "at risk, naturally uncommon, range restricted";
- **Northern royal albatross** *(Diomedea sanfordi)* – locally common endemic; IUCN "endangered" status; Toroa Operational Area within "species normal range"; DOC conservation status "at risk, naturally uncommon, range restricted";
- **Light mantled sooty albatross** *(Phoebetria palpebrata)* – uncommon native; vessel follower; appears at the coast in periods of high winds; IUCN "near threatened" status; Toroa Operational Area within "species full range" in coastal areas and "species normal range" in offshore areas; DOC conservation status "at risk, declining, data poor, range restricted, secure overseas";
- **Black-browed mollymawk** *(Thalassarche melanophris)* – common native; most commonly seen mollymawk; IUCN "near threatened" status; DOC conservation status "non-resident native, coloniser, threatened overseas"
- **Campbell Mollymawk** *(Thalassarche impavida)* – common endemic; vessel follower; IUCN "vulnerable" status; Toroa Operational Area within "species normal range"; DOC conservation status "at risk, naturally uncommon, island endemic, one location";
- **Shy mollymawk** *(Thalassarche cauta)* – uncommon visitor; vessel follower; IUCN "near threatened" status; DOC conservation status "non-resident native, vagrant, secure overseas";
- **White-capped mollymawk** *(Thalassarche steadi)* – locally common endemic; keen vessel follower; IUCN "near threatened" status; Toroa Operational Area within "species normal range" offshore and coastal "species hotspot"; DOC conservation status "at risk, declining, extreme fluctuations, range restricted";
- **Salvin's mollymawk** *(Thalassarche salvini)* – locally common endemic; keen vessel follower; IUCN "vulnerable" status; Toroa Operational Area within "species normal range"; DOC conservation status "threatened, nationally critical, range restricted, threatened overseas";
- **Chatham Island mollymawk** (*Thalassarche chryostoma*) – rare endemic; IUCN "vulnerable" status; Toroa Operational Area within species "full range"; DOC conservation status "at risk, naturally uncommon, island endemic, one location"

- **Grey-headed mollymawk** *(Thalassarche chrysostoma)* – locally common native; gathers around stationary boats; IUCN "endangered" status; Toroa Operational Area within "species normal range"; DOC conservation status "threatened, nationally vulnerable, one location, threatened overseas";
- **Buller's mollymawk** *(Thalassarche bulleri)* – locally common endemic; vessel follower; Toroa Operational Area within "species normal range" including a hotspot in the vicinity of the Toroa Operational Area around Solander Island group; IUCN "near threatened" status; DOC conservation status "at risk, naturally uncommon, range restricted";
- **Pacific mollymawk** *(Thalassarche nov spi. / platei)* – locally common endemic; vessel follower; not yet assessed by IUCN; DOC conservation status "at risk, naturally uncommon, range restricted";
- **Flesh-footed shearwater** *(Puffinus carneipes)* – common native; attracted to stationary vessels; migrates to North Pacific in the winter; IUCN "least concern" status; Toroa Operational Area within "normal species range"; DOC conservation status "threatened, nationally vulnerable, range restricted, threatened overseas";
- **Buller's shearwater** *(Puffinus bulleri)* – common endemic; migrates to America during the winter; IUCN "vulnerable" status; Toroa Operational Area within "species normal range"; DOC conservation status "at risk, naturally uncommon, one location, stable";
- **Sooty shearwater** *(Puffinus griseus)* – abundant native; migrates to northern pacific in the winter; IUCN "near threatened" status; Toroa Operational Area within the "species hotspot"; DOC conservation status "at risk, declining, secure overseas";
- **Little shearwater** *(Puffinus assimilis)* - locally common native; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Southern diving petrel** (*Pelecanoides urinatrix chathamensis)* – abundant native (*Pelecanoides* urinatrix), IUCN status "least concern", DOC conservation status "at risk, relict, range restricted";
- **South Georgian diving petrel** (*Pelecanoides georgicus*) – rare native; IUCN "least concern" status; Toroa Operational Area within species "normal range"; DOC conservation status "nationally critical, conservation dependant, island endemic, one location";
- **Grey petrel** (*Procellaria cinerea*) – uncommon native; IUCN "near threatened" status; DOC conservation status " at risk, naturally uncommon, range restricted, secure overseas;
- **Westland petrel** (*Procellaria westlandica*) – uncommon endemic; IUCN "vulnerable" status; Toroa Operational Area within "species full range"; DOC conservation status "at risk, naturally uncommon, one location, stable";
- **White chinned-petrel** (*Procellaria aequinoctialis*) – uncommon native; IUCN "vulnerable" status; Toroa Operational Area within species "full range"; DOC conservation status" at risk, declining, range restricted, threatened overseas";
- **Cape pigeon** *(Daption capense)* - common native; IUCN "least concern" status; DOC conservation status "non-resident native, secure overseas"
- **Antarctic fulmar** (*Fulmarus glacialoides*) – locally common visitor; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Southern giant petrel** *(Macronectes giganteus)* – common visitor; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Northern giant petrel** *(Macronectes halli)* – common native; IUCN "least concern" status; Toroa Operational Area within "species full range"; DOC conservation status "at risk, naturally uncommon, range restricted, secure overseas";
- **Fairy prion** *(Pachyptila turtur)* – locally abundant native; IUCN "least concern" status; DOC conservation status "at risk, relict, range restricted, secure overseas"
- **Fulmar prion** (*Pachyptila crassirostris*) – locally abundant native; IUCN "least concern" status; DOC conservation status "naturally uncommon, range restricted, stable"

- **Thin-billed prion** (*Pachyptila belcheri*) – common visitor; IUCN "least concern" status; DOC conservation status "non-resident native migrant, secure overseas";
- **Antarctic prion** *(Pachyptila desolata)* – locally common native; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, range restricted, secure overseas";
- **Salvin's prion** (*Pachyptila salvini*) – common visitor, IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Broad-billed prion** (*Pachyptila vittata*) – locally common native; IUCN "least concern"; DOC conservation status "at risk, relict, range restricted, secure overseas";
- **Cook's petrel** (*Pterodroma cookii*) – uncommon endemic; IUCN "vulnerable" status; DOC conservation status "at risk, relict, increasing, range restricted";
- **Mottled petrel** (*Pterodroma inexpectata*) – very rare endemic; IUCN "near threatened" status; DOC conservation status "relict, increasing, range restricted"
- **Kermadec white-faced storm petrel** *(Pelagodroma albictunis)* – locally common native; IUCN "least concern" status; DOC conservation status "nationally critical, island endemic, one location";
- **Grey-faced petrel** *(Pterodroma macroptera)* – common native; IUCN "least concern" status; Toroa Operational Area is within "normal full range"; DOC conservation status "not threatened, designated, increasing, range restricted";
- **White-headed petrel** (*Pterodroma lessonii*) – locally common native; IUCN "least concern", DOC conservation status "not threatened, designated, range restricted, secure overseas";
- **Soft-plumaged petrel** (*Pterodroma mollis*) – uncommon native; IUCN "least concern"; DOC conservation status "non-resident native, coloniser, increasing, one location, secure overseas";
- **Wilson's storm petrel** *(Oceanites oceanicus)* – locally common native; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **White-faced storm petrel** *(Pelagodroma marina)* – common native; IUCN "least concern" status; DOC conservation status "at risk, relict, range restricted";
- **Black-bellied storm petrel** (*Fregetta tropica*) – locally common native; IUCN "least concern"; DOC conservation status "not threatened, designated, range restricted";
- **Yellow eyed-penguin** (*Megadyptes antipodes*) – uncommon endemic; IUCN "endangered" status; Toroa Operational Area within "species normal range"; DOC conservation status "threatened, nationally vulnerable, extreme fluctuations"';
- **Gentoo penguin** (*Pygoscelis papua*) – rare subantarctic vagrant; IUCN "near threatened" status; DOC conservation status "non-resident native, vagrant, secure overseas";
- **Blue penguin** *(Eudyptula minor)* – common native; IUCN "least concern" status; DOC conservation status "at risk, declining, data poor, extreme fluctuations";
- **Rockhopper penguin** (*Eudyptes chrysocome*) – locally common native; IUCN "vulnerable" status; DOC conservation status "nationally critical, range restricted, threatened overseas";
- **Fiordland crested penguin** (*Eudyptes pachyrhynchus*) – rare endemic; IUCN "vulnerable" status; DOC conservation status "nationally endangered, sparse";
- **Snares crested penguin** (*Eudyptes robustus*) – locally common endemic; IUCN "vulnerable" status; DOC conservation status "at risk, relict, naturally uncommon";
- **Erect-crested penguin** (*Eudyptes sclateri*) – locally common endemic; IUCN "endangered" status; DOC conservation status "at risk, declining";

- **Australasian gannet** *(Morus serrator)* – common native; common in coastal waters and harbours and estuaries; IUCN "least concern" status; DOC conservation status "not threatened, designated, increasing, secure overseas";
- **Black shag** *(Phalacrocorax carbo)* – common native; seen in sheltered coastal waters, lakes and rivers; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, secure overseas, sparse";
- **Pied shag** *(Phalacrocorax varius)* – locally common native; IUCN "least concern" status; DOC conservation status "threatened, nationally vulnerable";
- **Little shag** *(Phalacrocorax melanoleucos)* - common native; IUCN "least concern" status; DOC conservation status "not threatened, increasing";
- **Stewart Island shag** (*Phalocrocorax chalconotus*) – locally common endemic; IUCN "vulnerable" status; DOC conservation status "threatened, nationally vulnerable"
- **Bounty Island shag** (*Phalocrocorax ranfurlyi*) – locally common endemic; IUCN "vulnerable" status; DOC conservation status "threatened, nationally endangered, island endemic, one location";
- **Spotted shag** *(Phalacrocorax punctatus)* - locally common endemic; IUCN "least concern" status; DOC conservation status "not threatened";
- **Brown skua** (*Catharacta skua*) – locally common native; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, sparse";
- **South polar skua** (*Catharacta maccormicki*) – occasional annual visitor; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Arctic skua** *(Stercorarius parasiticus)* - common arctic migrant; occurs in coastal waters of NZ in summer; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Pomarine skua** *(Stercorarius pomarinus)* - uncommon arctic migrant; occurs in coastal and oceanic waters of NZ in summer; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Black-backed gull** *(Larus dominicanus)* – abundant native; occurs in most coastal areas; IUCN "least concern" status; DOC conservation status "not threatened, secure overseas";
- **Red-billed gull** *(Larus novaehollandiae)* – abundant native; occurs in most coastal areas; IUCN "least concern" status; DOC conservation status "threatened, nationally vulnerable";
- **Black-billed gull** *(Larus bulleri)* – endangered endemic; Toroa Operational Area within species "normal range"; IUCN "endangered" status; DOC conservation status "threatened, nationally critical, recruitment failure";
- **White-winged black tern** *(Chlidonias leucopterus)* – uncommon Eurasian migrant; occurs in sheltered coastal waters and coastal lagoons; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Black-fronted tern** *(Sterna albostriata)* – locally common endemic; IUCN "endangered" status; Toroa Operational Area within the normal around the South Island coast and full range around Stewart Island; DOC conservation status "threatened, nationally endangered, recruitment failure, sparse";
- **Caspian tern** *(Hydroprogne caspia)* – reasonably common native; occurs in sheltered coastal waters, harbours and estuaries; IUNC "least concern" status; Toroa Operational Area is within the "normal coastal species range"; DOC conservation status "threatened, nationally vulnerable, small increasing population (unnatural), secure overseas, sparse";
- **White-fronted tern** *(Sterna striata)* – abundant endemic; occurs in inshore NZ waters; IUCN "least concern" status; DOC conservation status "threatened, nationally vulnerable, data poor, range restricted";

- **Antarctic tern** (*Sterna vittata*) – locally common native; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **Little tern** *(Sterna albifrons)* – uncommon Asian migrant; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- **White tern** *(Anous tenuirostris)* – rare native; IUCN "least concern" status; Toroa Operational Area within "species full range"; DOC conservation status "threatened, nationally critical, conservation dependant, one location, secure overseas".

#### *4.2.7.1 Seabird Breeding Areas*

New Zealand has been recognised to have the "highest number of endemic breeding seabird species worldwide" (Croxall *et al.*, 2012). Numerous seabird colonies are known to breed along the south Dunedin and south Southland coasts (minimum 120 km away from the Toroa Operational Area) (Parkinson, 2006; MPI, 2014f; NZ Birds online, 2014b). These species are listed below and the locations of the main breeding areas for all species are displayed on the map in Figure 25.

- Antarctic tern (*Sterna vittata*) – Breeding: Sept-Mar
- Australasian Gannet (*Morus serrator)* – Breeding: Aug-Mar
- Black-backed gull *(Larus dominicanus)* – Breeding: Sept-Mar
- Black-browed mollymawk (*Thalassarche melanophris)* – Breeding: Sept-May
- Black-billed gull *(Larus bulleri)* – Breeding: Aug-Mar
- Black-fronted tern (*Sterna albostriata)* – Breeding: Oct-Jan
- Black shag *(Phalacrocorax carbo)* – Breeding: Jan-Dec
- Blue penguin (*Eudyptula minor)* – Breeding: Jul-Feb
- Broad-billed prion (*Pachyptila vittata)* - Breeding: Aug-Jan
- Brown skua (*Catharacta skua*) – Breeding: Sept-Feb
- Cape pigeon (*Daption capense)* - Breeding: Nov-Feb
- Caspian tern (*Hydroprogne caspia)* - Breeding: Sept-Jan
- Codfish island Georgian diving petrel (*Pelecanoides georgicus)* - Breeding: Sept-Feb
- Cook's petrel (*Pterodroma cookii*) - Breeding: Sept-Apr
- Fairy prion (*Pachyptila turtur)* - Breeding: Oct-Feb
- Fiordland crested penguin (*Eudyptes pachyrhynchus)* - Breeding: Jul-Dec
- Fulmar prion (*Pachyptila crassirostris)* - Breeding: Oct-Feb
- Light mantled sooty albatross (*Phoebetria palpebrata)* - Breeding: Aug-Apr
- Little shag *(Phalacrocorax melanoleucos)* – Breeding: Aug-Mar
- Mottled petrel (*Pterodroma inexpectata)* - Breeding: Dec-May
- Northern Giant Petrel (*Macronectes halli)* - Breeding: Dec-May
- Northern royal albatross (*Diomedea sanfordi)* - Breeding: Jan-Dec
- Pied shag (*Phalacrocorax varius)* - Breeding: Jan-Dec
- Red-billed gull (*Larus novaehollandiae)* - Breeding: Sept-Jan
- Salvin's albatross (*Thalassarche salvini)* - Breeding: Sept-Apr
- Sooty shearwater (*Puffinus griseus)* - Breeding: Nov-May
- South polar skua (*Catharacta maccormicki*) - Breeding: Sept-Feb
- Southern Buller's albatross *(Thalassarche bulleri)* - Breeding: Oct-Jun
- Spotted shag (*Phalacrocorax punctatus*) - Breeding: Jan-Dec
- Stewart Island shag (*Phalocrocorax chalconotus)* - Breeding: Aug-Mar

- White-fronted terns (*Anous tenuirostris*) - Breeding: Oct-Jan
- Yellow-eyed penguin (*Megadyptes antipodes*) - Breeding: Aug-Apr

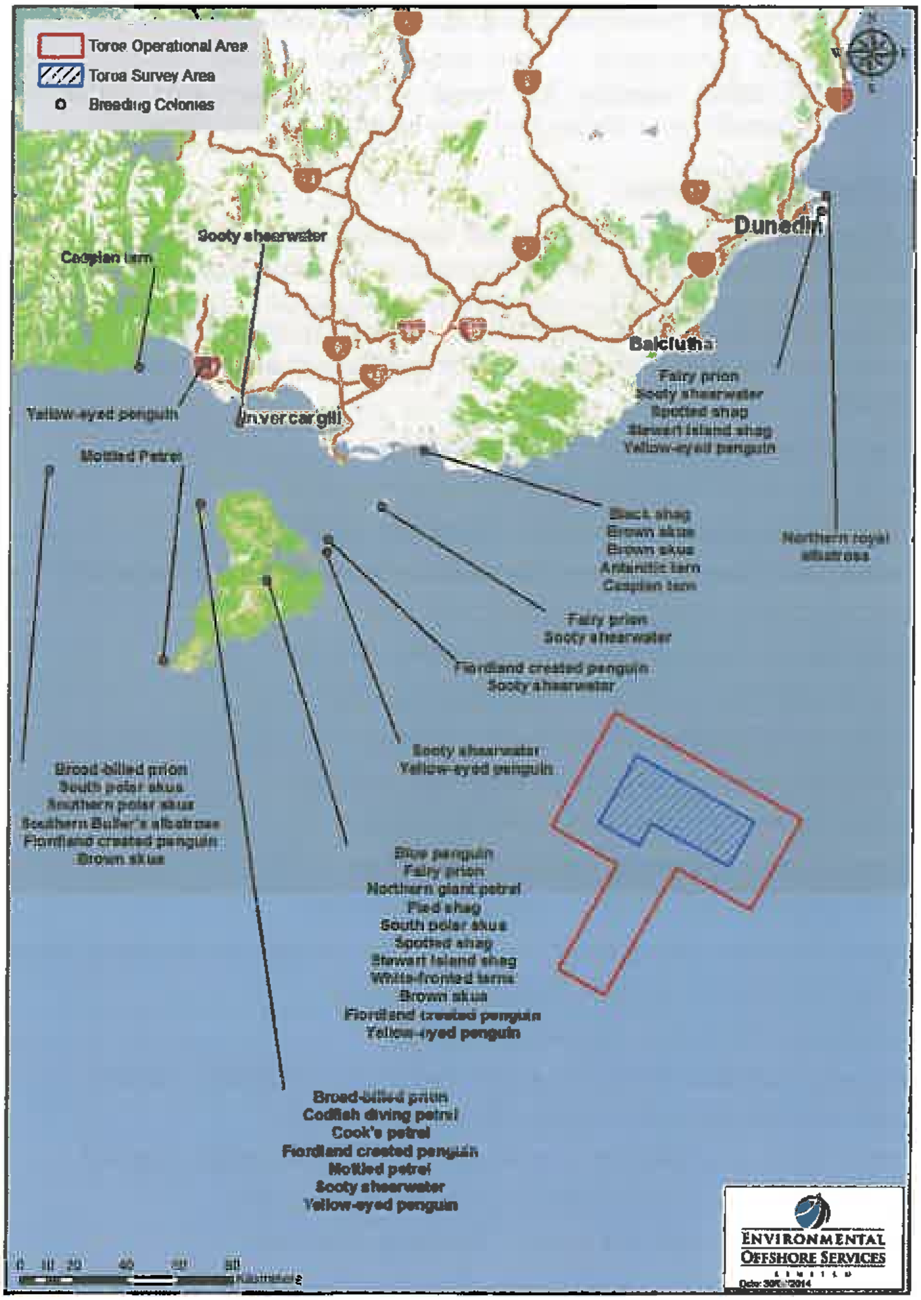


**Figure 25: Breeding colonies surrounding the Toroa Operational Area**

### *4.2.7.2 Species of Particular Interest*

The sooty shearwater (Titi) is of particular concern given the special traditional relationship of Ngai tahu Māori with this species (see Section 4.3.5). The section below will give a brief overview of the biology of the species.

#### *4.2.7.2.1 Sooty Shearwater*

Sooty shearwaters are common south of Banks Peninsula. They are known to congregate in flocks of tens of thousands in the waters around Stewart Island and the South Island. The NZ population is estimated to be about 21 million birds (NZ Birds online, 2014c).

Breeding colonies are distributed around the south of NZ and Stewart Island. Stewart Island and its outliers host numerous sooty shearwater breeding colonies as does the Otago coastline (12 mainland colonies with up to 620 burrows (Hamilton *et al.*, 1997)). Internationally, the species also breeds on islands off Australia, Chile and the Falklands. The breeding season in NZ extends between September/October and May (NZ Birds online, 2014c).

The species is monogamous and both sexes share the tasks of incubation and chick care. Every year, a single egg is laid in a chamber at the end of a burrow. Although birds return to the same area to breed from one year to the next, they may not use the same burrows. The egg is laid between the end of November and the beginning of December; incubation takes 53-56 days; and chicks will fledge at around 86-106 days at which point they are independent (NZ Birds online, 2014c).

During breeding, adult sooty shearwater will take regular "foraging trips" out to sea. These trips can either be "long trips" during which the birds will feed in subantarctic waters (Shaffer *et al.*, 2009; Raymond *et al.*, 2010) or "short trips" during which foraging is concentrated along the NZ continental shelf edge (with activity concentrated along the southeast coast of NZ) (Shaffer *et al.*, 2009). It is thought that the purpose of these two types of trip (also observed in other seabird species) is to balance both adult and offspring energetic demands.

During feeding, the birds will dive to depths of around 15 m for up to 100 seconds (Shaffer *et al.*, 2009); however, they have been recorded to dive to depths of 68 m (Shaffer *et al.*, 2006). Most of this diving activity will take place during the day (Shaffer *et al.*, 2009).

Their diet consists of fish, cephalopods and crustaceans (Cruz *et al.*, 2001). At sea, sooty shearwater abundance has been observed to correlate with rich zooplankton communities available in the subantarctic and foraging sites have been correlated to upwelling, primary production, prey availability and wind patterns. In addition, foraging site fidelity has been demonstrated in this species with animals returning to the same sites from one year to the next (Raymond *et al.*, 2010).

Sooty shearwaters are known to undergo a post-breeding migration which sees them travel up to the waters of the Northern Pacific (either central, eastern or northern pacific). This Pacific migration phase is understood to last 192 ± 17 days (Shaffer *et al.*, 2006) (see Figure 26). Birds travel northwards between March-May and return to NZ breeding colonies in September-December (Spear & Ainley, 1999). During this migration, the birds follow a figure of eight pattern which is thought to be influenced by global phenomena such as wind circulation and the Coriolis effect (Shaffer *et al.*, 2006). The birds' arrival in the Northern Pacific is timed with an increase in oceanic productivity in the area which exceeds that of the Southern Ocean. It is thought that this species seeks biologically productive areas both during its breeding season (in the Southern Ocean) and during winter (in the North Pacific).

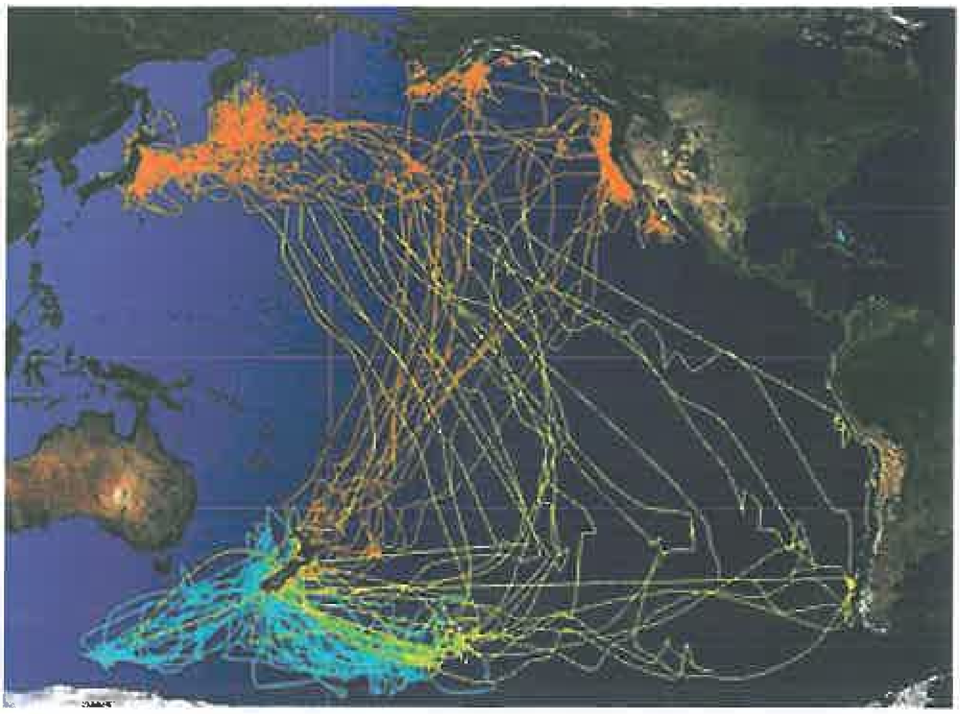

**Figure 26: Tracks of 19 sooty shearwaters. Blue: foraging trips to the southern ocean. Yellow: beginning of the northward migration. Orange: foraging in the North Pacific and return southwards (Shaffer *et al.*, 2006).**

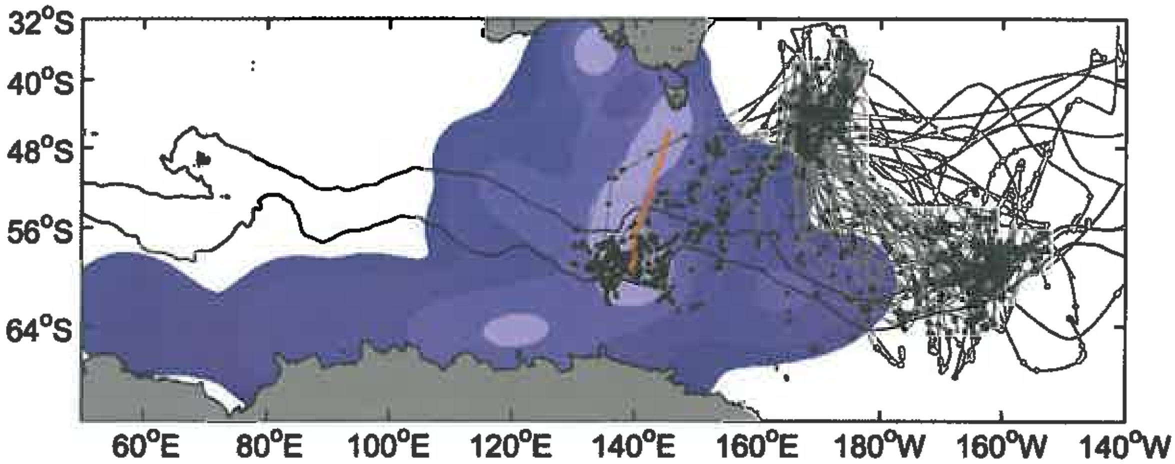


**Figure 27: Sooty shearwater foraging trips in the subantarctic waters and along the NZ continental shelf (dots=dives) (Raymond *et al.*, 2010)**

#### *4.2.7.2.2 Royal albatross (Toroa)*

There are two species of royal albatross: the northern royal albatross and the southern royal albatross. The southern is marginally larger than the northern and the two species can be distinguished at sea by differences in the patterns on their wings. Both species are commonly seen throughout the Southern Ocean and most commonly in NZ waters during the winter (Parkinson, 2006; DOC, 2014e; NZ Birds online, 2014a, 2014e).

Breeding occurs exclusively in NZ waters and egg laying takes place between October and December. The northern royal albatross breeds on the Chatham Islands and at Taiaroa Head on the Otago Peninsula (see Section 4.3.1.1), whereas the southern royal albatross breeds mainly on the subantarctic Auckland and Campbell Islands with a few birds hybridising with its northern counterpart at Taiaroa Head. Both species mate for life and each albatross pair will rear a single chick every two years. Outside of these breeding periods, albatross will spend most of their life at sea (DOC, 2014e).

Royal albatross cover large distances during foraging trips over the continental shelves and up to shelf edges (up to 190,000 km in a year) (DOC, 2014e; NZ Birds online, 2014a). Breeding birds generally forage over the continental shelf and inner slope of southern NZ, the Chatham Rise, and over Campbell Plateau. Non-breeding and immature birds will undertake a downwind circumnavigation of the Southern Ocean which takes them into South American waters (NZ Birds online, 2014a, 2014e). The birds feed mainly on fish and cephalopod species. Discards from fishing boats can constitute a large portion of the diet for this species.

Current breeding population estimates are of 6,500-7,000 pairs of Northern Royal Albatross including 30 pairs breeding at Taiaroa Head (<1% of the population) and 8,500 pairs of Southern Royal Albatross.

#### *4.2.7.2.3 Yellow-eyed penguin (Hoihoi)*

Yellow-eyed penguins occur off the south-east of the South Island, Stewart Island, Campbell Island and Auckland Islands (DOC, 2014k; NZ Birds online, 2014g). Mainland NZ breeding locations include four distinct areas: the Catlins, Otago Peninsula, North Otago and Banks Peninsula (NZ Birds online, 2014g). On Stewart Island, breeding occurs principally on the northern and eastern coastline.

A particularity of this species is that it relies equally on marine and terrestrial habitat. Mature forests and regenerated scrubland provide nesting and loafing ground whereas the marine environment provides food and allows the species to range between land-based habitat (DOC, 2014k).

A clutch of two eggs is generally laid between September and October. Incubation takes between 39 and 51 days, and is followed by two periods of chick rearing: the guard phase during which the chick is constantly brooded and the post-guard phase during which chicks are left alone at the nest during the day (NZ Birds online, 2014g).

Adults of the species undertake daytime foraging trips to the mid shelf region and range between 2 and 25 km (up to depths of 120 m) and shorter evening trips (<7 km) (Mattern *et al.*, 2007). Prey species include sprat, red cord, opalfish, ahuru, silversides, blue cod, cephalopods and crustaceans (Moore, 1999; NZ Birds online, 2014g). Yellow-eyed penguins are known to use a benthic-diving strategy not only during feeding but also during their trips out to the foraging sites. Additionally, tracking data have demonstrated that individuals of the species will re-visit the same sites on foraging trips (Mattern *et al.*, 2007)

The current population estimates lies between 6,000 and 7,000 individuals including around 600 breeding pairs on the South Island and 180 pairs on Stewart Island (NZ Birds online, 2014g).

#### *4.2.7.2.4 Stewart Island shag*

The Stewart Island shag is a NZ endemic species which presenting a fairly restricted range. The species breeds in the coastal waters and harbours of the South Island between Waitaki River and Te Wae Wae Bay, and Stewart Island (NZ Birds online, 2014f).

The species nests in colonies and the timing of breeding will vary between colonies. One to three eggs are laid between September and November (NZ Birds online, 2014f).

Prey species include fish and crustaceans and flocks of Stewart Island shags have been reported foraging up to 10 km off the Otago Coast (NZ Birds online, 2014f).

#### *4.2.7.2.5 Codfish Island Georgian diving petrel*

This rare native's NZ breeding grounds are limited to Codfish Island (near Stewart Island). Nests are located in the sand dunes within 100 m of the sea. Adults will generally return to the colonies dusk and will be nocturnally active in the colonies (NZ Birds online, 2014d).

Worldwide, this species is known to forage in cold water near convergence zones and on the edge of the continental shelf where they will spend most of the day underwater. Although their diet in NZ is poorly studied, it is thought that krill and copepod are important food sources to this species (NZ Birds online, 2014d.

The NZ population of this species holds less than 150 individual animals making is one of the rarest birds in the country (NZ Birds online, 2014d).

## 4.3 Coastal and Marine Conservation

### 4.3.1 Regional Coastal Environment

The Toroa Operational Area extends over a section of the south-east coast of the South Island of NZ. The area inshore of the Toroa Operational Area within the Coastal Marine Area (CMA) is the responsibility of Otago Regional Council and Environment Southland (Figure 28). Each Council has within their jurisdiction a range of different habitats and areas of significance that are unique to that region. The following section provides an overview of the regional coastal environments inshore of the Toroa Operational Area.

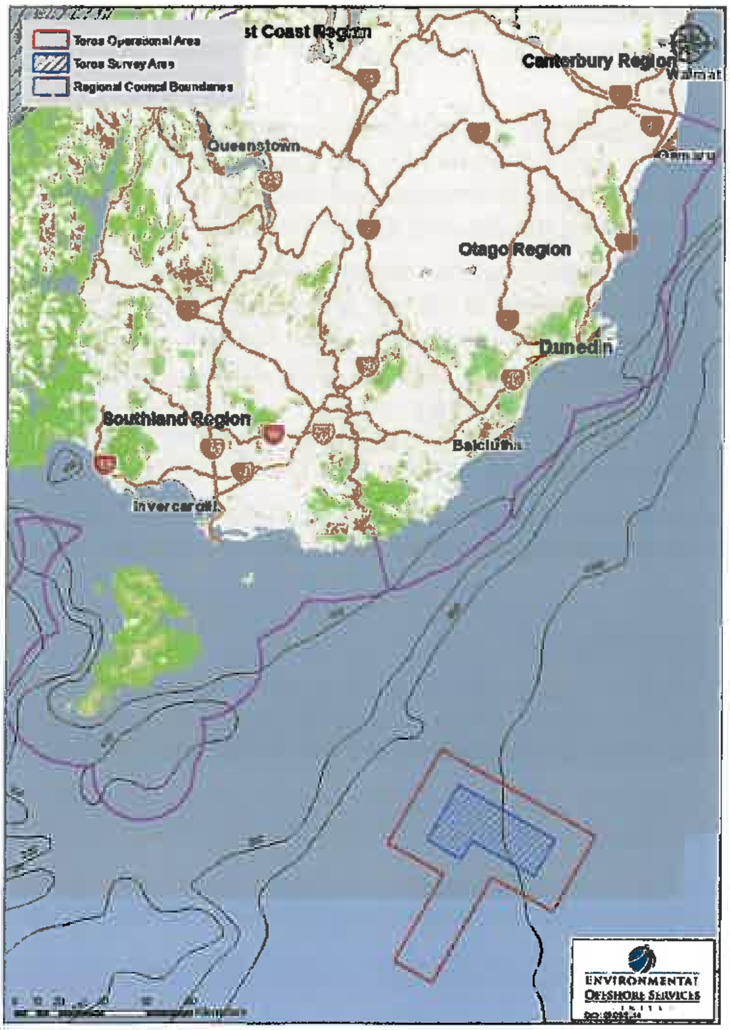


**Figure 28: Regional Council Boundaries**

#### 4.3.1.1 Otago Coastline

The sites listed below are defined as "coastal protection areas" by the Otago Regional Council (Otago Regional Council, 2012). Coastal protection areas include any zone below the mean high water springs considered to be of regional, national, or international importance in terms of their ecological and scenic values, and including areas which have spiritual or cultural significance. Other classifications defined by the council include: coastal development areas, coastal recreation areas, and coastal harbour side areas. By dividing the coastline into these areas, Otago Regional Council aims to address the issues of recognition of each type of coastal area and its values, and preservation of amenities, cultural, historical, scenic and ecological values into the future.

The coastal protection areas classified as important by the Otago Regional Council include: Blueskin Bay; Orokonui Inlet; Mapoutahi; Purakanui Inlet; Aramoana; Historic Otago Harbour walls; Otakou & Taiaroa Head; Pipikaretu Point; Te Whakarekaiwi; Papanui Inlet; Hoopers Inlet; Kaikorai Estuary; Brighton; Akatore Estuary; Tokomairiro Estuary Wangaloa; Clutha River/Mata-Au, Matau Branch; Nugget Point; Surat Bay; Jacks Bay; Catlins Lake Estuary; Waiheke Beach; Tahakopa Estuary; Oyster Bay; Tautuku Estuary; Waipati Estuary, and Kinakina Island.

These coastal protection areas listed above are displayed in Figure 29.

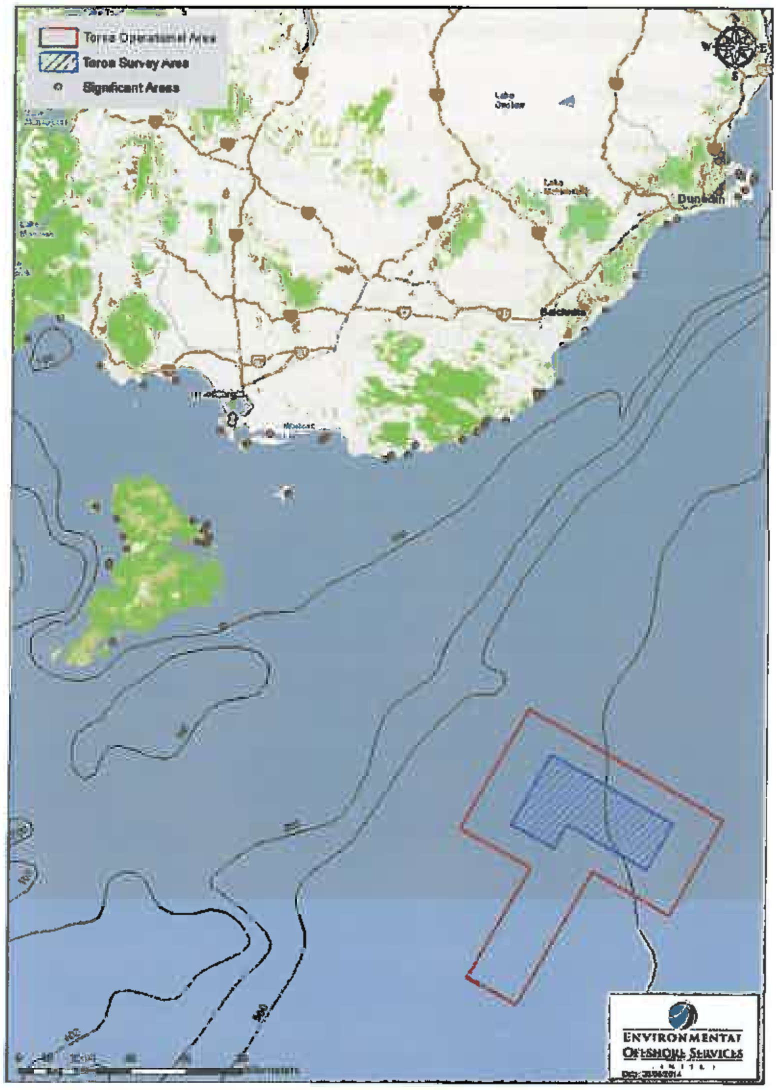


**Figure 29: Otago coastal protection areas and Southland significant areas**

Conservation Management Strategy for Otago published by DOC further highlights features of the Otago coastline while establishing a strategy for their future preservation. These features include (but are not limited to) (DOC, 2013b):

- Tuna/eels and various *Galaxiids* (including giant kokopu and other whitebait species) in the Otago waterways
- Tahakopa Bay, Tautuku and Waipiti Beaches and their threatened and at-risk saltmarsh and dune insects
- Feeding and breeding habitat for resident marine mammals (NZ fur seal, NZ sea lion) and haul-out sites for vagrant marine mammal species (southern elephant seal, leopard seal) (see Section 4.2.4)
- Feeding and breeding sites many species of birds (shags, gulls, shearwaters, prions, penguins and terns) including the threatened/at risk yellow-eyed penguin, northern royal albatross, Stewart Island shag, spotted shag, and blue penguin (see Section 4.2.7)
- Protected marine species such as great white sharks and basking sharks (see Section 4.2.3)
- Stalked barnacle (*Ibla idiotiza*), brachiopod (*Pumilus antiquatus*) and an unclassified polychaete worm (see Section 4.2.2)

### 4.3.2 Southland Coastline

The Environment Southland Regional Coastal Plan identifies values of the marine coastal area. These include marine mammals and birds; ecosystem, vegetation, and fauna habitats; natural character and landscape values; areas of significant conservation value; heritage and archaeological values; coastal landforms and associated processes; recreational and amenity values; commercial values; education values; and anchorage value. A summary of the relevant values for the section of the Southland in the vicinity of the Toroa Operational Area is provided in Table 10 and shown in Figure 29.

**Table 10: Values described in the Environment Southland Regional Coastal Plan (Environment Southland, 2013)**

| Coastal Area | Marine mammals and birds | Ecosystem, vegetation and fauna habitats | Natural character and landscape values | ASCV |
|---|---|---|---|---|
| Waitutu Coast (Big River to Track Burn | Fiordland crested penguin; NZ fur seal; NZ sea lion; Buller's Mollymawk; Sperm whales; Southern right whales | Sand Hill Point (*Euphorbia glauca*); Solander Islands | Marine terraces cut into soft tertiary rocks and uplifted by tectonic movements | Marine Terraces; Solander Islands |
| Te Waewae Bay (track Burn to Pahia Point) | Hector's dolphin; Southern right whale; Spotted shag; Oyster catchers; Banded dotterel; Mottled petrel | Toheroa beds; Surf clams; Coastal wetlands; Estuaries; Lagoons | Natural coastline | Te Waewae Lagoon to Track Burn stream |
| Pahia Point to Jacobs River Estuary | N/A | N/A | Diversity of landscape | N/A |
| Jacobs River Estuary and Lower Pourakino Rover | Caspian tern; Australasian bittern; Variable oystercatcher; Banded dotterel; Shoveller; Paradise duck | Mud flats; Sand flats; Marginal vegetation; Flatfish nursery | Sandy beaches fringed by forest margin and rockwalls | N/A |
| Jacobs River Estuary to Stirling Point | Hector's dolphin; Southern right whale; NZ fur seals; Yellow-eyed penguin; Omaui Island bird breeding ground (shags, gulls, blue penguins, sooty shearwaters, royal spoonbills) | Toheroa beds; Surf clams; Flatfish nursery; Dune system; Insect habitat; Pingao and *Gunnera hamiltonii* | Rocky shores; Exposed coastline; Pingao communities; Carpets of low, salt-tolerant plants | New River Estuary |
| New River Estuary | Wading bird and waterfowl species (sandpiper, tattlers, greenshanks, south island pied oyster catchers, banded dotterel); South Island fernbird | Wetland complexes; Rearing and spawning habitat for marine and freshwater species (giant kokopu, lamprey, long-finned eel); Marsh to sand dune totara forest | Salt marsh or indigenous scrub | Estuary (important nursery for fish and invertebrates) |
| Bluff Harbour and Awarua Bay | Migratory waders (Siberian tattler, sandling, Stewart Island sub-species of the NZ dotterel); Local waders; Waterfowl (black swans) | Wading bird habitat; Flounder nursery; "Machair" coastal vegetation | Indigenous vegetation; Ventifacts | Awarua Bay |
| Tiwai Point to Fortrose | Southern right whales; Hector's dolphins; Birds (black-backed | Subalpine shrub; Waituna Wetlands Scientific Reserve; | Shingle beaches; Gravel bars; Duneland; Native vegetation; Peat | Area extending 1 km seaward from Fortrose |

| Coastal Area | Marine mammals and birds | Ecosystem, vegetation and fauna habitats | Natural character and landscape values | ASCV |
|---|---|---|---|---|
| | gulls, oyster catchers, banded dotterel, Stewart Island Shags) | Lobster and paua (abalone) fisheries off Ruapuke and Green Islands | bogs; Lagoons; Estuaries; Salt marshes; Tidal flats | Spit |
| Toetoes Estuary | Hector's dolphin; NZ fur seal | Flatfish breeding ground; Whitebait fishery | Indigenous vegetation; Riparian vegetation | Seaward area of the estuary |
| Fortrose to Brothers Point | Hector's dolphin; Yellow-eyed penguin; NZ fur seal; NZ sea lion | Dolphin habitat; Commercial paua (abalone) fishing prohibition | Bay; Sand dunes; Headlands; Sea cliffs; Rocky reefs | Slope Point to Brothers Point |
| Coastal Area | Marine mammals and birds | Ecosystem, vegetation and fauna habitats | Natural character and landscape values | ASCV |
| Waikawa Harbour and Haldane Estuary | Waterfowl; Waders; Hector's dolphin | Flounder breeding areas; Whitebait and giant kokopu habitat; Eel and lamprey migration through estuary waters; Wetland of National Importance to fisheries | Waikopikoiko stream catchment; Rocky cliffs | Waikawa Harbour; Haldane Estuary |
| Stewart Island and Islands Offshore (including Ruapuke, Titi, Codfish and Big South Cape) | NZ fur seals; NZ sea lion; Leopard seal; Reef heron; NZ dotterel; Trans-equatorial and northern migrant waders; Shags; Terns; Gulls; Yellow-eyed penguin; Fiordland crested penguins; Blue penguins; Bottlenose dolphin; Dusky dolphin; South Georgian diving petrel; Cooks petrel; Southern Skua; Mottled petrel; Storm petrel; Diving petrel; Shearwaters; Shags | Black coral colonies; Brachiopod communities; Oyster beds containing fragile and diverse lace coral, mollusc and sponge communities; Feeding habitat for wader species; Whitebait habitat; Long-finned eel habitat; Giant kokopu and banded kokopu habitat; NZ dotterel habitat; Seaweed diversity; Banded dotterel habitat;- Phytoplankton productivity | Estuarine mudflats; Sheltered waters; Dune system; Sandy shores | Stewart Island (and its offshore islands) |

### 4.3.3 New Zealand Marine Environmental Classification

MfE, MPI and DOC commissioned NIWA to develop an environmental classification called the NZ Marine Environment Classification (NZMEC). The NZMEC covers NZs Territorial Sea and EEZ to provide a spatial framework for structured and systematic management. To do so, geographic domains are divided into units that have similar environmental and biological characters (MfE, 2005).

Within the classification system, physical and biological factors (depth, solar radiation, sea surface temperatures (SST), waves, tidal current, sediment type, seabed slope and curvature) were used to classify and map marine environments around NZ.

The Toroa Operational Area falls within NZMEC groups 47, and 170 representing the moderately shallow waters on the continental shelf out to deep water (Figure 30) and are described below following the categories defined by NIWA (MfE, 2005).

**Class 47** occurs extensively in deep waters (mean = 2,998 m) over a latitudinal range from around 37–47° S. Average chlorophyll *α* concentrations are moderately low. Characteristic fish species (24 sites) include smooth oreo, Baxter's lantern dogfish, the rattail *Macrourus carinatus*, Johnson's cod and orange roughy.

**Class 170** is extensive in moderately shallow waters (mean = 129 m) on the continental shelf surrounding the Chatham Islands, and from Foveaux Strait south, including around the Bounty Islands, Auckland Islands and Campbell Island. Annual solar radiation and wintertime SST are both moderately low, as is the annual amplitude of SST. Tidal currents are moderate and average concentrations of chlorophyll *α* reach moderate levels. Some of the most commonly occurring fish species are barracouta, spiny dogfish, hapūku and ling, while arrow squid are taken with very high frequency in trawls. The most commonly represented benthic invertebrate families are Terebratellidae, Serpulidae, Veneridae, Pectinidae, Temnopleuridae, Carditidae Cardiidae, Glycymerididae, Spatangidae and Limidae.

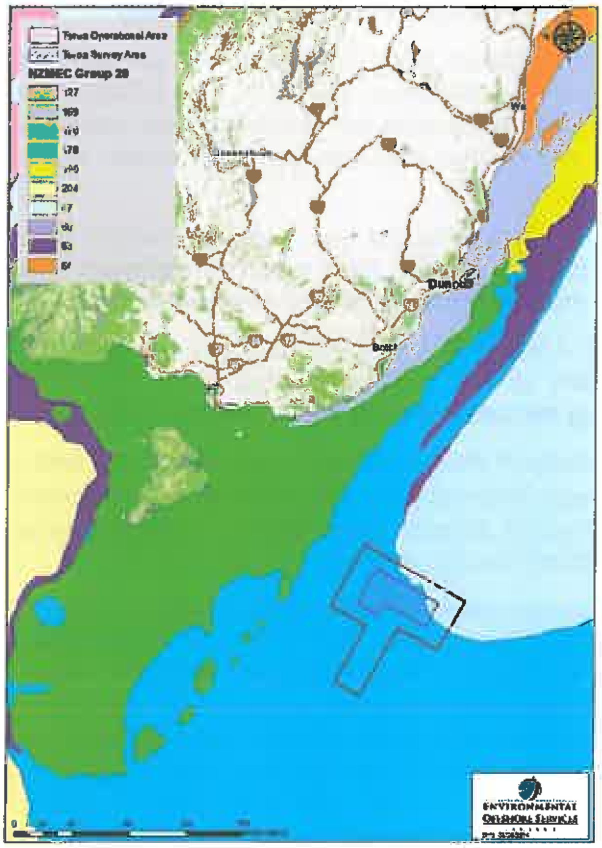

**Figure 30: NZEMC zones in and around the Toroa Operational Area**

### 4.3.4 Protected Natural Areas

Protected Natural Areas (PNA) are put in place for biodiversity conservation and receive protection varying degrees of protection as a result of their recognised natural ecological values. There are numerous different types of PNAs which include national parks, conservation parks, nature reserves, scientific reserves, and scenic reserves.

They are managed under six main pieces of legislation Conservation Act 1987, National Parks Act 1980, Reserves Act 1977, Wildlife Act 1953, Marine Reserves Act 1971, and the Marine Mammals Protection Act 1979

The main PNAs in the vicinity of the Toroa Operational Area are detailed below.

#### *4.3.4.1 Coastal Protected Natural Areas*

**Taiaroa Head** (Pukekura) is subdivided into a wildlife sanctuary, nature reserve and a local purpose reserve (wildlife protection, maritime safety, cultural and visitor facilities) and is co-managed by Korako Karetai Trust, Te Runanga o Otakou, DOC and Dunedin City Council. The reserves recognise the significance of the site in terms of ecology, culture, history, public appreciation, tourism and commerce (Dunedin City Council *et al.*, 2013). The most important ecological feature of Taiaroa Head is its unique royal albatross colony. Numerous other seabirds also nest and feed on the headland including Stewart Island shags, little shags, spotted shags, sooty shearwaters, etc. (see Section 4.2.7.1). NZ fur seals breed on the rocks and beaches around the headland and NZ sea lions regularly haul out in the area as do the occasional elephant and leopard seal (see Section 4.2.5).

**Nugget point** is a scientific reserve. This area is recognised for its seabird breeding colonies and the marine wildlife that occurs in the surrounding areas (yellow-eyed penguins, fur seals, sooty shearwaters).

**Sand Fly Bay** is a recreational reserve which is recognised for the presence of yellow-eyed penguins. Other bird species such as spotted shags and sooty shearwaters also occur in the area, and fur seals and NZ sea lions are known to haul out on the beach (DOC, 2014f).

**Shag Point** (Matakaea) is jointly managed by DOC and Te Runanga o Ngāi Tahu. The site holds the status of topuni which contributes to publicly recognizing the mana (authority) of Ngāi Tahu over the site (DOC, 2014g). Shag Point is recognised for the occurrence of species such as yellow-eyed penguins, NZ fur seals. In addition, the area is steeped in Māori history (see Section 4.3.5).

**Rakiura National Park** (Stewart Island) opened in 2002 and is New Zealand's 14th national park. The park covers approximately 157,000 hectares and 85 percent of Stewart Island/Rakiura (Figure 31). It encompasses a network of former nature reserves, scenic reserves, and state forest areas (including reserves such as the Ulva Island Open Sanctuary). Marine species of importance which occur within the park include seals (see Section 4.2.5), penguins and numerous bird species (see Section 4.2.7).


**Figure 31: Rakiura National Park**
**Source:** www.doc.govt.nz

#### *4.3.4.2 Marine Protected Natural Areas*

Inshore of the Toroa Operational Area is the **Catlins Coast Marine Mammal Sanctuary**, and the **Te Waewae Bay Marine Mammal Sanctuary** (Figure 32).

The Catlins Coast MMS extends from Three Brother's Point offshore 5 nm to a point 6.9 nm offshore to Bushy Point Beacon. The sanctuary is approximately 65,967 hectares and covers 161 km of coastline.

The boundary of the Te Waewae Bay Marine Mammal Sanctuary is a line from Pahia point to Sand Hill Point (see Section 4.3.4). The area covers approximately 35,906 hectares and covers 112.93 km of coastline. Seismic surveys are regulated inside both of these MMS in accordance with the Marine Mammals Protection Notices 2008.

There are also set net restrictions imposed in these areas by the Fisheries Act. The use of set nets is prohibited in the Southland Fishery Management Area from Slope Point to Sandhill Point, east of Fiordland – offshore to four nautical miles. Set netting is also prohibited in the whole of Te Waewae Bay between Old Man Rock, west of Garden Bay and Sandhill Point.

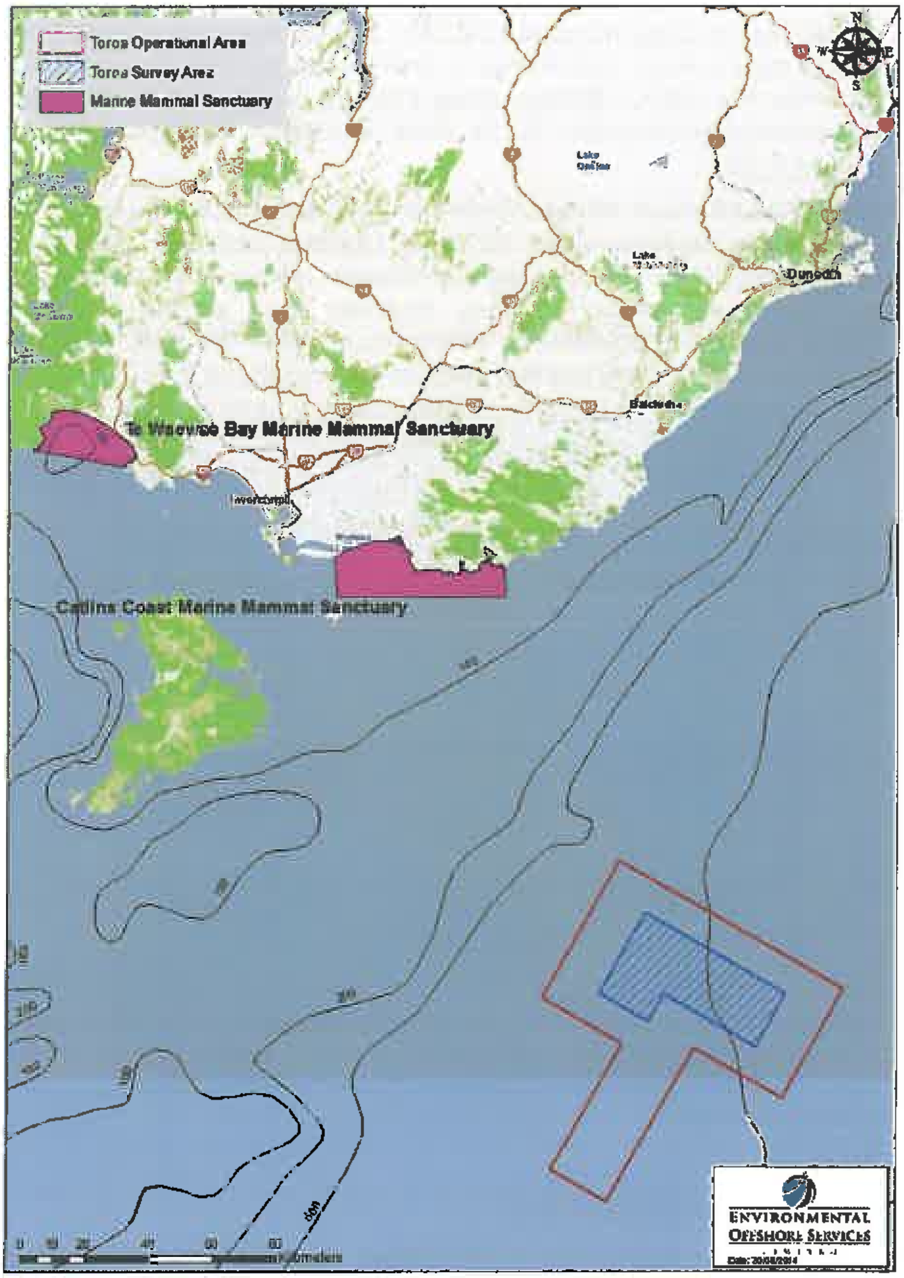


**Figure 32: Te Waewae Bay and Catlins Coast marine mammal sanctuaries**

**Ulva Island Marine Reserve** (Te Wharawhara Marine Reserve) is located within Paterson Inlet on the east coast of Stewart Island (Figure 33). The reserve was established in 2004 and covers 1,075 hectares. Surrounding waters are part of the Te Whaka a te Wera Mātaitai (see Section 4.3.6.1). The marine reserve status provides full protection to the marine wildlife within the reserve. Seals and seabirds are often observed feeding in the area and the reserve is used as a nursery by numerous fish and shellfish species. In addition, Ulva Island Reserve is one the richest and most accessible habitats for brachiopods in the world and also hosts the highest diversity of seaweed in NZ (56 brown, 31 green, 174 red seaweed species) (DOC, 2014i).

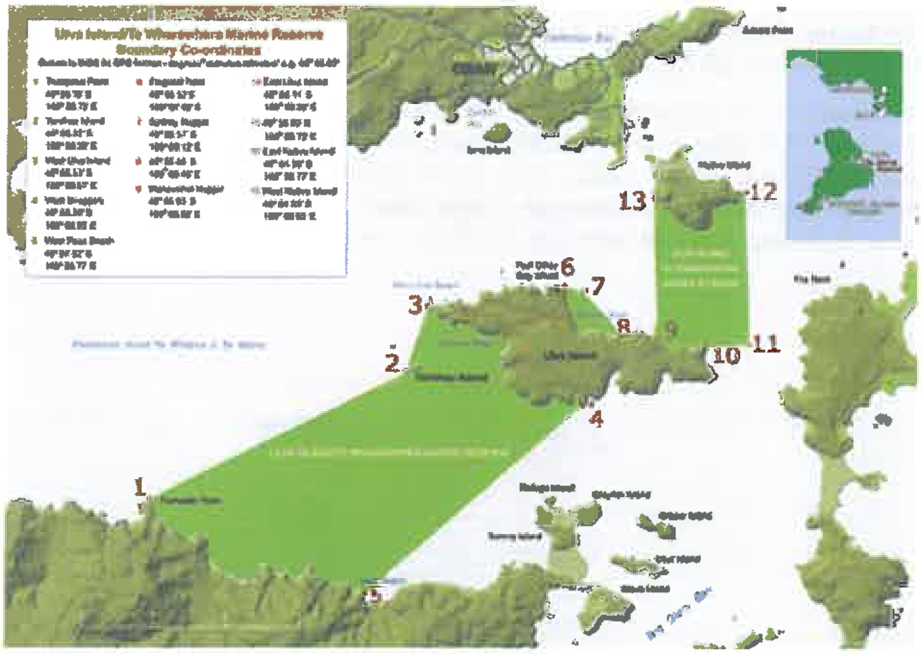


**Figure 33: Ulva Island marine reserve**
**Source: www.doc.govt.nz**

### 4.3.5 Cultural Environment

The concept of whakapapa is fundamental to Māori culture. It is defined as the "genealogical descent of all living things from gods to the present time" (Barlow, 1994). Since whakapapa is extended beyond the sphere of the living to things such as rocks and mountains, it implies not only a strong sense of genealogy, but also the interconnectedness of the Māori people and the natural environment.

Māori believe in the importance of protecting Papatuanuku (the land) including the "footprints and stories left on the whenua (land) and wai (water) by our ancestors" (Nga Uri O Tahinga Trust, 2012). This is exemplified by the role of kaitiakitanga (guardian) which is passed down from generation to generation within an iwi. The role is central to the preservation of waahi tapu ("*a place sacred to Māori in the tradition, spiritual, religious, ritual, or mythological sense*" (The Historic Places Act, 1993) and taonga (treasures).

In particular, Tangaroa (the seas, oceans and fish) is treasured by all Māori coastal communities. It is valued as a source of kaimoana and commercial fisheries, for its estuaries and coastal waters, for its waahi tapu and spiritual pathways and its uses for transport and communication (Nga Uri O Tahinga Trust, 2012). The conservation of many of these natural features is discussed in other sections of the report but it is important to stress their equal cultural, spiritual and historical significance to coastal Māori iwi. As custodians of the rohe moana (*A coastal and marine area over which an iwi or a hapū exercises its mana and its kaitiakitanga (MfE, 2014)*), kaitiakitanga call upon ancestral knowledge to manage the natural resources.

According to Māori tradition, the first explorer of the South Island coastline was Maui. He circumnavigated the island and then pulled up a stone from the sea to use as an anchor for his waka. He named this stone Puka o Te Waka o Paui (Rakiura/Stewart Island) (Environment Southland, 2013). Other areas of the south of NZ are similarly steeped in traditional histories. Te Ara a Kiwa (The Foveaux Strait) is another of these. Becoming tired of having to cross the land which joined Southland to Stewart Island, Kiwa requested that Kewa should chew a passage between the two. Kewa thus created the Strait, leaving behind crumbs that had fallen from his mouth (the islands in Foveaux Strait) and a loose tooth (Solander Island/Te niho a Kewa). For Māori, these landmarks represent the link between current generations and the world of the gods, thus reinforcing tribal identity and whakapapa (Environment Southland, 2013).

Within human history, the coastal area of Southland was visited successively by Waitaha, Ngati Mamoe and Ngāi tahu who eventually merged in the whakapapa of Ngāi tahu Whanui (Environment Southland, 2013). Today, the iwi of Ngāi tahu includes 18 Papatipu Runanga and a governing body called Te Runanga o Ngāi tahu. Ngāi tahu takiwa (ancestral land) is defined by the Te Runanga Ngāi tahu Act 1996 and covers much of the South Island (Figure 34).

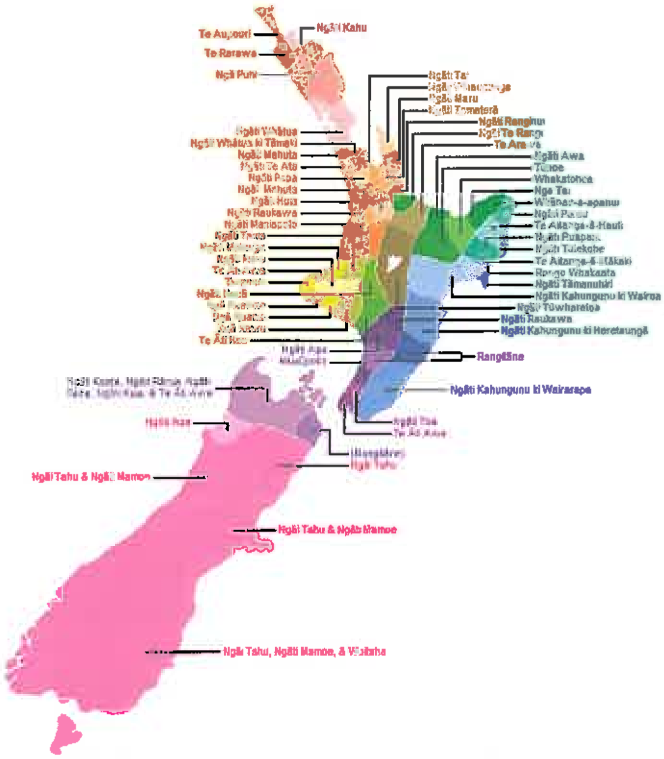


**Figure 34: New Zealand Iwi boundaries**

The South Island coastline is regarded by Ngāi tahu as extremely valuable from both a spiritual and physical perspective (Otago Regional Council, 2012). The resources provided by this environment (e.g. kaimoana) have been primordial in the survival of generations of the iwi; so much so that the protocols involved in managing and preserving these resources are now deeply embedded in the culture of Ngāi tahu (Otago Regional Council, 2012). As kaitiaki (guardians) of the coastline, Ngāi tahu endeavour to maintain the cultural link to the marine environment and promote a holistic approach to the conservation of natural resources for future generations (Otago Regional Council, 2012).

Waahi tapu are numerous within the Ngāi tahu takiwa. These include (but are not limited to) pā, middens, caves, urupa, kaimoana gathering sites, and ancient moa processing sites (Cannibal Bay, Pounawea, Papatowai, Tautuku) (DOC, 2013b). Much of these are the result of transient villages setting up and moving between hunting and fishing sites.

These sites are spread throughout Otago and Southland in areas adjacent to the Toroa Operational Area.

In Southland, notable areas include Te Waewae (Waiau), Taunoa (Orepuki), Kawakaputaputa (Wakaputa), Oraka (Colac Bay), Aparima (Riverton), Turangiteuaru, Awarua (Bluff), Te Whera, and Toe Toe. The islands located off the coast of the South Island also hold particular cultural importance. Rarotoka (Centre Island) was used as a safe-haven during conflicts and is still used a navigational marker to this day. The islands in

Foveaux Strait hold a prominent place in local Māori culture as titi gathering grounds (sooty shearwater). Titi was not only used as sustenance but also as a tradable commodity (Te Runanga o Ngāti Rianui, 2014) (see Section 4.3.5.1). Whenau Hau (Codfish Island) is said to be one of the stopping places used by Ngāi tahu on the way to the Titi Islands. It was also the site of the first integrated Māori/European settlements. Stewart Island is equally significant with many pa sites, middens, kaimoana (sea food) and mahi kai (birds) gathering sites along its coastline.

On the Otago coastline, Matakaea (Shag Point) is regarded as wahi taonga by Ngāi tahu and the area is one of two topuni in Otago. Matakaea is believed to stand guard over inland Otago and is the site of numerous waahi tapu and urupa. The name Matakaea recalls the tradition of the Arai Te Uru canoe, which capsized off Moeraki. The crew swam ashore, fled inland and were subsequently transformed into mountains. As a result, the canoe and its cargo where washed ashore. The Arai Te Uru canoe is said to have carried kumara from Hawaiiki to Aotearoa, along with the karakia (incantations) and tikanga (customs) connected with planting it successful (DOC, 2014h). Further north along the Otago coastline, Pukekura (Taiaroa head) also holds the status of waahi tapu due to the extent of archaeological materials found or preserved there. Amongst other historical features, a palisaded pā is thought to have run from the harbour side of the headland to the ocean side.

The cultural and spiritual importance of these sites was recognised in the Cultural Redress included in the Crown's Settlement Offer package for this region. In addition, the Ngāi tahu Claims Settlements Act 1998 acknowledges the importance of the relationship between Ngāi tahu and taonga species occurring in the South Island. A list of the marine and estuarine taonga species can be found in Table 11. Iwi place value in the taonga species listed below and all other marine mammals including species such as beaked whales and their environment. These animals have been seen to provide for the iwi in the past and now, in turn, the iwi must provide for them (Jolly, 2014). This is why Ngāi tahu actively participate in the preservation of these species.

**Table 11: Ngāi tahu taonga species**

| Māori name | English name | Scientific name |
|---|---|---|
| Hoihoi | Yellow-eyed penguin | *Megadyptes antipodes* |
| Kaki | Black stilt | *Himantopus novaezelandiae* |
| Kamana | Australasian crested grebe | *Podiceps cristatus* |
| Koau | Black, pied and little shag | *Phalocrocorax carbo, P. varios, P. melanoleucos* |
| Korora | Blue penguin | *Eudyptula minor* |
| Kotare | Kingfisher | *Halcyon sancta* |
| Kotuku | White heron | *Egretta alba* |
| Kowhiowhio | Blue duck | *Hymenolaimus malcorhynchus* |
| Kuaka | Bar-tailed godwit | *Limosa lapponica* |
| Kuruwhengu | NZ shoveler | *Ana rhynchotis* |
| Matuku moana | Blue reef heron | *Egretta sacra* |
| Ngutu pare | Wrybill plover | *Anarhynchus frontalis* |
| Parera | Grey duck | *Anas aucklandica* |
| Poaka | Pied stilt | *Himantopus himpantopus* |
| Pokotiwha | Snares crested penguin | *Eudyptes robustus* |
| Tarapirohe | Black-fronted tern | *Sterna albostriata* |
| Tarapunga | Black-billed gull | *Larus bulleri* |
| Tawaki | Fiordland crested penguin | *Eudyptes pachyrhynchus* |
| Titi | Sooty shearwater/Hutton's shearwater | *Puffinus griseus/P. huttoni* |
| Titi | Common diving, South Georgian & Westland petrel | *Pelecanoides urinatrix, P. Georgicus & Procellaria westlandica* |
| Titi | Fairy prion & broad-billed prion | *Pachyptila turtur, P. vittata* |
| Titi | White-faced storm petrel, Cook's & Mottled petrel | *Pelagodroma marina, Pterodroma cookie & P. inexpectata* |
| Torea | Pied oystercatcher | *Haematopus ostralegus* |
| Toroa | Albatross and mollymawks | *Diomedea spp.* |
| Turiwhatu | Banded dotterel | *Charadrius bicintus* |
| Ihupuku | Southern elephant seal | *Miroung leonine* |
| Kekeno | NZ fur seal | *Arctocephalus forsteri* |
| Paikea | Humpback whale | *Megaptera novaeangliae* |
| Parao | Sperm whale | *Physeter Macrocephalus* |
| Rapoka/whakahoa | Hooker's sea lion | *Phocarctus hookeri* |

#### *4.3.5.1 Titi gathering (mutton-birding)*

Titi is among the taonga species recognised by the Ngāi tahu Claim settlement in 1998.

The harvest of titi is the only remaining native wildlife harvest managed entirely by Māori. In particular, the species has a key cultural, economic and social significance for Rakiura Māori and they hold the rights to gather titi on 36 islands surrounding Stewart Island/Rakiura (also known as Titi Islands). Eighteen of these islands are named "Beneficial Islands" to which only certain Rakiura Māori families hold the ownership and right of access. The remaining 18 islands are known as the Rakiura Titi Islands and, since the Ngāi tahu Claim settlement act in 1998, are owned and controlled by Rakiura Māori (Te Ara, 2014b).

Titi harvesting is known as mutton-birding. The harvest takes place between 1st April and 31st May. There are two stages of harvesting. The first stage goes from the 1st-22nd April and is called the nanao. This is when mutton-birders take chicks from their burrows during daylight. The second stage is called rama and lasts from 23rd April to 31st May. During rama, mutton-birders work at night and catch chicks as they emerge from their burrows to exercise their wings (Te Ara, 2014b). The daily take is limited by the time it takes to pluck and process the birds the next day. The total estimate of chicks taken per annum is 400,000 (NZ Birds online, 2014c).

A summary of the biology of this species is given in Section 4.2.7.2.

### 4.3.6 Customary Fishing

As stated in previous sections of the report, Māori people maintain a strong relationship with the sea and the collection of kaimoana is a fundamental part of their life. For coastal hapū, kaimoana is often vital to sustain the mauri (life force) of tangata whenua (people of the land). It allows Māori to provide a food source for whānau (family) and hospitality to manuhiri (guests). Critically, the ability to provide reasonable amounts of these foods to their visitors is a marker of a tribe's mana and status (Tainui Waikato, 2013). Traditional management of the marine environment entails a whole body of knowledge on the sea's natural resources, their seasonality and the manner in which they can be harvested. This customary wisdom is held sacred by tangata whenua and only passed on to those who will look after it.

A rohe moana is composed of areas where kaitiaki are appointed for the management of customary kaimoana collection within the rohe under the Kaimoana Customary Fishing Regulations (1998). The Customary Fishing Regulations allow hapū to: appoint tangata kaitiaki; establish management controls; give authorisation (or permits) to exercise customary take; specify responsibility for those acting under the customary fishing regulations; provide penalties to be imposed for breach of the regulations; and to allow for restriction or prohibitions over certain fisheries areas to prevent depletion or overexploitation.

As previously illustrated, the collection of kaimoana is widespread along the entirety of the coastline considered in this report and the list of taonga species is extensive. Species concerned include marine species such as Tuaki (cockles), pipi, paua (abalone), mussels, toheroa, tio (oysters), pupu (mudsnails), cod, barracouta, octopus, patiki (flounders), seaweed, kina, koura (crayfish), conger eel, ling, hapūka; and estuarine species including tuna (eels), inanga (whitebait), waikoura (freshwater crayfish), kokopu, and kanakana (lamprey).

#### *4.3.6.1 Taiapure and Mātaitai*

The Fisheries (Kaimoana Customary Fishing) Regulations (1998) allows traditional management to govern the fishing practices within an area that is deemed significant to tangata whenua. Under these regulations, tangata whenua are able to establish management areas (Mātaitai reserves) to oversee fishing within these areas and create management plans for their overall area of interest.

Mātaitai comprise of traditional fishing grounds established for the purpose of recognising and providing kaimoana collection and customary management practices. Commercial fishers cannot fish within a Mātaitai reserve; however, recreational fishers can. Tangata whenua are also able to exercise their customary rights through a customary fishing permit under the Fisheries (Amateur Fishing) Regulations 1986.

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

There are eight customary fishing reserves in the vicinity of the Toroa Operational Area which are displayed in Figure 35 and listed below:

- Waikawa Harbour Mātaitai (commenced 09/10/2014 and measuring 7 $km^2$);
- Waitutu Mātaitai (commenced 07/08/2014 and measuring 2 $km^2$);
- Oreti Mātaitai (commenced 08/07/2010 and measuring 16 $km^2$);
- Motupohue Mātaitai (commenced 8/07/2014 and measuring 7 $km^2$);
- Te Whaka a Te Wera Mātaitai (commenced 08/07/2014 and measuring <1 $km^2$);
- Horomamae Mātaitai (Titi Islands) (commenced 08/07/2014 and measuring <1 $km^2$);
- Pikomamuka Mātaitai (Titi Islands) (commenced 08/07/2014 and measuring <1 $km^2$); and
- Kaihuka Mātaitai (Titi Islands) (commenced 08/07/2014 and measuring <1 $km^2$).

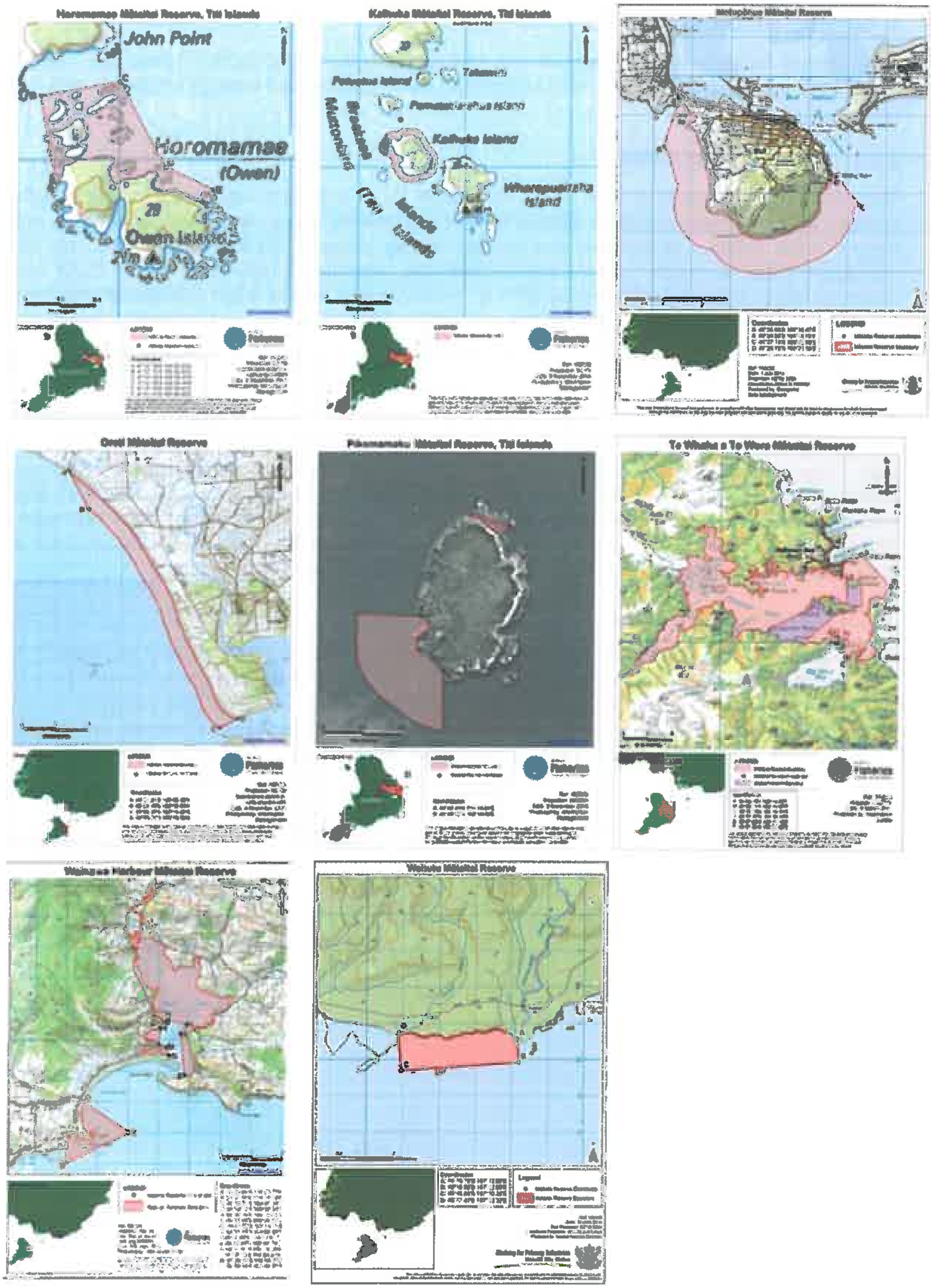


**Figure 35: Mātaitai reserves in the area adjacent to Toroa Operational Area (first line right to left: Horomamae Mātaitai, Kaihuka Mātaitai, Motupohue Mātaitai; second line right to left: Oreti Mātaitai, Pikomamuku, Te Whaka a Te Wera Mātaitai; third line right to left: Waikawa Harbour Mātaitai, Waritutu Mātaitai).**

## 4.4 Anthropogenic Environment

This section focuses on the users of the environments surrounding the Toroa Operational Area; with particular emphasis on recreational and commercial fishing, shipping, and the petroleum industry.

### 4.4.1 Recreational Fishing

The marine environment is now being accessed for recreational fishing by an increasing number of people with a relative degree of success; mainly due to improving technology and bigger faster boats. Unlike the commercial fishing industry, recreational fishers are not managed under a quota system; but instead are regulated under daily catch limits and minimum legal sizes established by MPI to preserve fish stocks from overexploitation and conserve them for the future generations.

The Toroa Operational Area is unlikely to be fished by recreational fishers due to the distance offshore (115 km) and the depth of water (600 m – 1,000 m).

The areas within and adjacent to the Toroa Operational Area support significant fisheries for Barracouta, Blue cod, Blue moki, Bluenose, Bronze whaler shark, Butterfish/Greenbone, Eels, Elephant fish, Flatfish, Grey mullet, Groper/Hapūku/Bass, Hammerhead shark, Herring, Kahawai, Lamprey, Ling, Mako shark, Marblefish, Pilchard, Porbeagle shark, Red cod, Red gurnard, Red moki, Rig, Sand flounder, School shark, Seven gilled shark, Skate ray, Spiny dogfish, Stargazer, Tarakihi, Thresher shark, Trevally, Trumpeter, Warehou, Wrasse, Cockle, Kina, Mussels, Dredge oyster, Paua, Scallops, Toheroa, Tuatua, Rock lobster.

### 4.4.2 Commercial Fishing

Ten Fisheries Management Areas (FMA) have been implemented within NZ waters to manage the Quota Management System (QMS). These areas are regulated by MPI (Figure 36). Over 1,000 fish species occur in NZ waters (Te Ara, 2014d) and QMS provides for the commercial utilisation of 96 species while ensuring sustainability. These species are divided into separate stocks and each stock is managed independently to ensure the sustainable utilisation of that fishery.

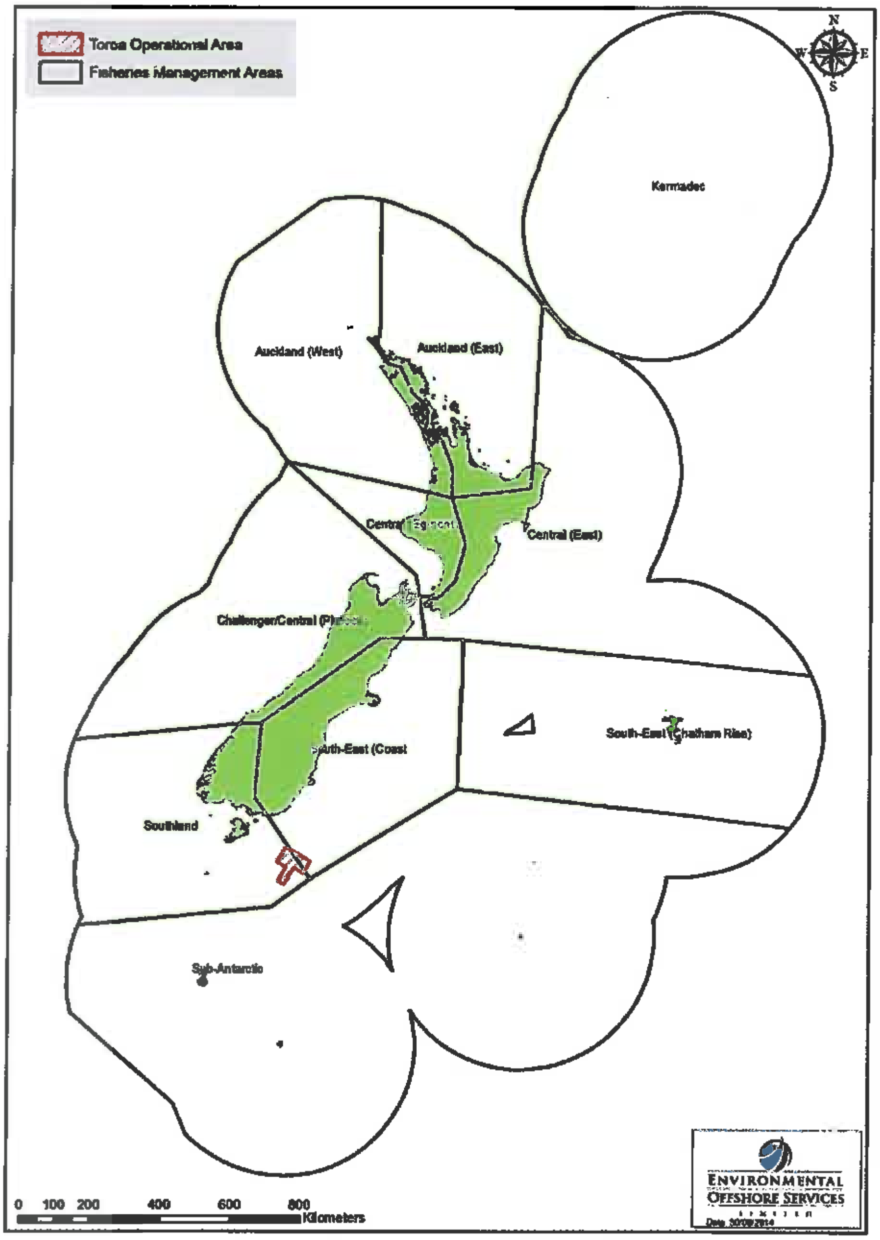


**Figure 36: Fisheries management areas within NZ waters**

Within NZ, the commercial fishing activities are closely monitored. In 2009, the calculated asset value of NZ's commercial fish resource was $4.017 billion, an increase of 47% from 1996 (Statistics NZ, 2014). The top 20 species of fish contributed 91% of the value of NZ's commercial fish resource; with hoki contributing 20% alone.

MPI undertook an analysis of fishing effort specifically for the Toroa Operational Area for the 2008/09 – 2012/13 fishing years. These data has been used to provide a summary of commercial fishing activities and which species are targeted (MPI, 2014g).

Data was analysed for all fishing events that started, passed through or ended within the Toroa Operational Area. The estimated catch of the top five species from fishing events that started, passed through or ended within the Toroa Operational Area is shown in Table 12, with hoki being the only species targeted.

**Table 12: Top species caught in the Toroa Operational Area during 2008/09 – 2012/13 fishing year (tonnes)**

| Species | Total (Tonnes) |
|---|---|
| Hoki | 331 |
| Other | 64 |
| Total | 395 |

The only type of fishing method used within the Toroa Operational Area is trawling. The number of fishing events by fishing method that started or ended in the Toroa Operational Area during the 2008/09 – 2012/13 fishing years can be seen in Figure 37. No trawling events were reported in any of the years covered for the months of July, August and September.

**Table 13: Fishing events by method within the Toroa Operational Area during 2008/09 – 2012/13**

| Method | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | Total |
|---|---|---|---|---|---|---|
| Trawl | 12 | 8 | 7 | 16 | 6 | 49 |

Fishing activity mainly occurs inshore along the western edge of the Toroa Operational Area with the exception of a few clustered events occurring in the centre of the area and along the southwestern boundary (Figure 37).

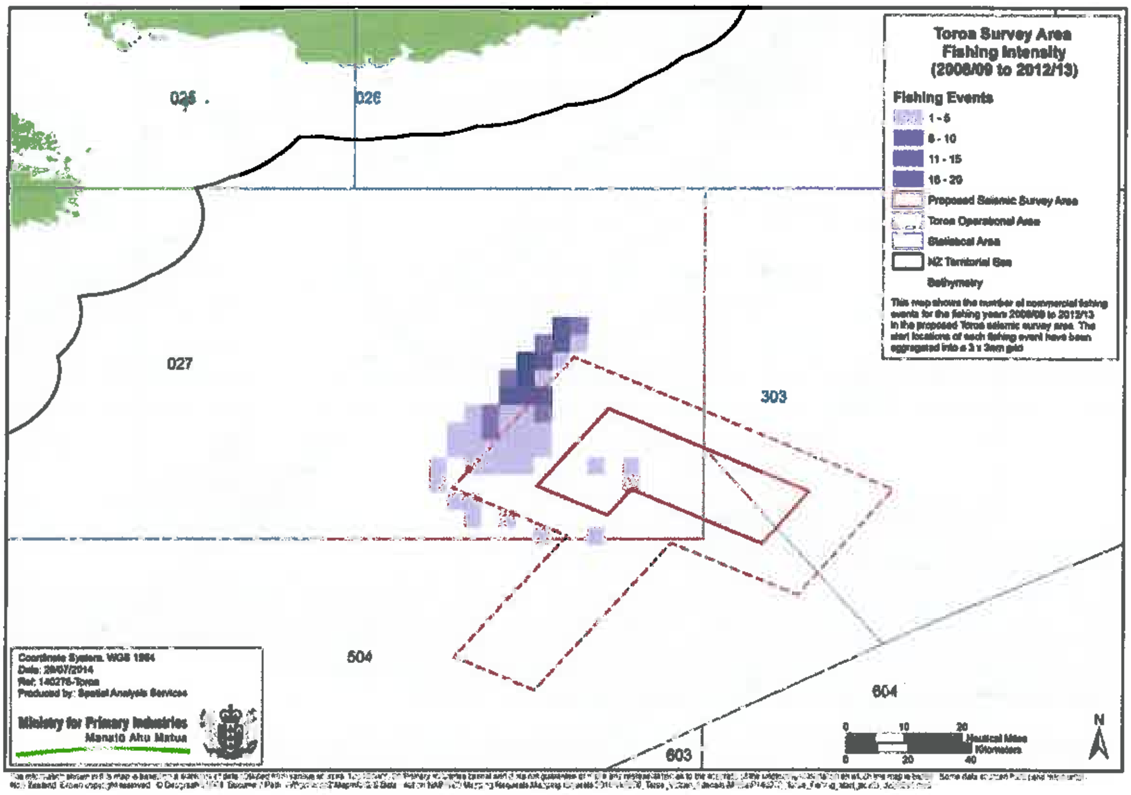


**Figure 37: Intensity of fishing activity in and around the Toroa Operational Area based on aggregated data from the 2008/09 to 2012/13 fishing years**

The fishing industry has been notified of the proposed Toroa 3D MSS (Appendix 2) and approximate commencement date, with all groups and fishers that utilise the area notified.

Consultation has been undertaken with Deepwater Group, Sanfords, Independent Fisheries, Maruha (NZ) Ltd, Talley's, Sealord, NZ Federation of Commercial Fisherman to advise them of the proposed Toroa 3D MSS and the array of gear that will be behind the *Polar Duke*. A summary of the engagements is provided in Appendix 2. These companies will be provided with contact details of the vessel closer to the commencement date.

A Notice to Mariners will be issued for the Toroa 3D MSS and will be available through the Linz website, or alternatively if pre-registered, the Notice to Mariners will be emailed directly once issued. As well as receiving the Notice to Mariners, all Mariners should routinely monitor the coastal navigation warnings which will have the details of the Toroa 3D MSS and can provide more timely access to important navigation safety information.

#### *4.4.2.1 Squid and Scampi Fisheries*

Two important fisheries also exist to the south of the Toroa Operational Area; the squid fishery and scampi fishery.

Scampi are widely distributed in NZ waters and found mainly at depths of 200-500 m (MPI, 2014c). In the vicinity of the Toroa Operational Area, their distribution follows the bathymetric features and the species is mainly found along the continental shelf and on the Auckland Islands shelf (Figure 38). The main fishing grounds are to the west of Foveaux Strait and to the southeast of Auckland Islands.

The scampi fisheries provided approximately $11 million in export earnings in 2008. The majority of New Zealand caught scampi is exported to Canada, Japan and the USA (MPI, 2014c).

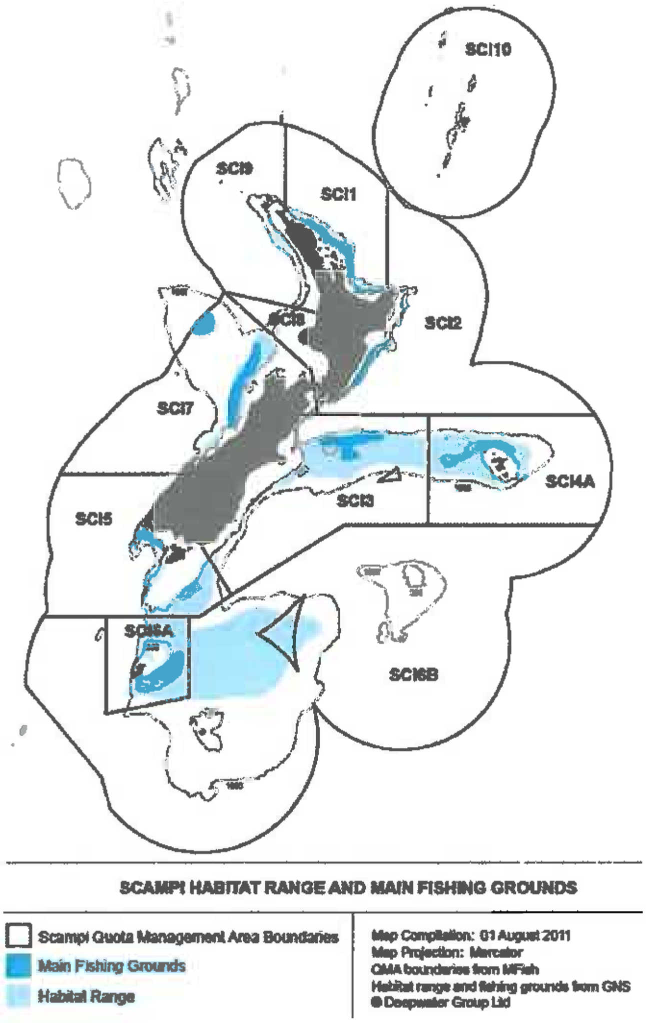


**Figure 38: Scampi habitat and main fishing grounds**

There are two species of squid which make up the NZ squid fishery: *Nototodarus gouldii* and *Nototodarus sloanii*. Squid are widespread across the NZ continental shelf generally in water depths of less than 300 m (MPI, 2014d).

The main fishing grounds in the vicinity of the Toroa Operational Area are located along the edge of the continental shelf, off the southeast coast of the South Island and Stewart Island (Figure 39). In addition, to the south, there are fishing grounds around the Auckland Islands shelf (Figure 39). The squid fishery is seasonal with the majority of squid fishing activity taking place in the summer months from January through to May.

In 2010/2011, 37,304 tonnes of squid (from a total allocation of 127,332 tonnes) was harvested from the NZ squid fishery. Annual catches of squid vary greatly from one year to the next due to the natural variability of the species' abundance, and since 2004/2005 there has been a general decreasing trend of catch rates. Squid quota value across all fisheries was estimated to be worth $95m in 2008 (MPI, 2014d).

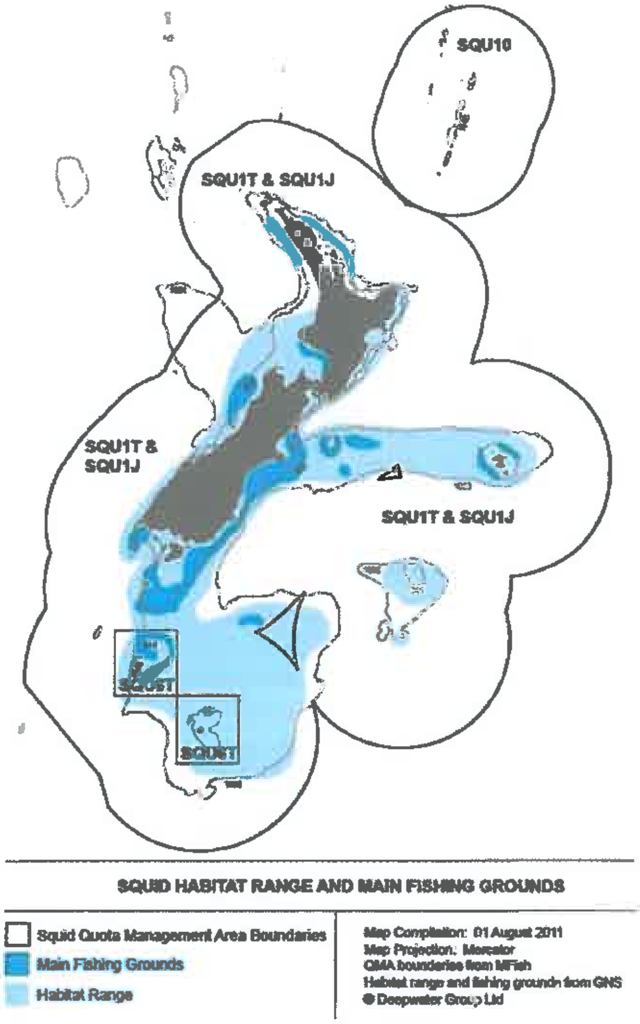


**Figure 39: Squid habitat and main fishing grounds**

### 4.4.3 Commercial Shipping

There are thirteen major commercial ports and harbours within NZ, consisting of major ports, river ports and breakwater ports. Ports are important gateways for freight, transport and trading both nationally and internationally. The closest ports to the Toroa Operational Area are at Bluff, Dunedin and Port Chalmers.

Commercial shipping vessels generally use the most direct path when travelling between ports. There is no dedicated shipping lane; vessels will generally take the shortest route with consideration of the weather conditions and forecast at the time. The general shipping routes between NZ ports are shown in Figure 40 and Figure 41. The Toroa Operational Area is located offshore from the shipping route between Bluff and both Dunedin and Port Chalmers. However, the route to subantarctic Islands (Campbell Island and Auckland Island) will take vessels through the Toroa Operational Area (Figure 40). As a result, the ports along the east and south coast of the South Island will be notified.

A Notice to Mariners will be issued ahead of the Toroa 3D MSS commencing and with adherence of all vessels to the COLREGS there should be no conflict between shipping vessels and the *Polar Duke*. The routes for foreign destinations from NZ ports is likely to vary and has not been included in Figure 41 although it is likely they could pass through or in close proximity to the Toroa Operational Area.

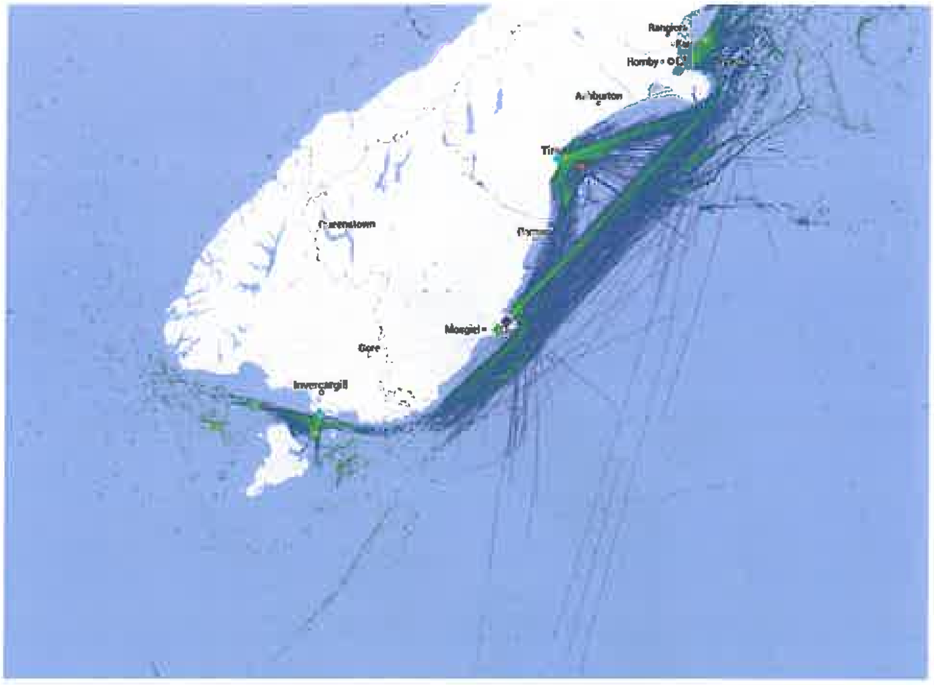


**Figure 40: Marine traffic density map for the Toroa Operational Area** (source: www.marinetraffic.com)

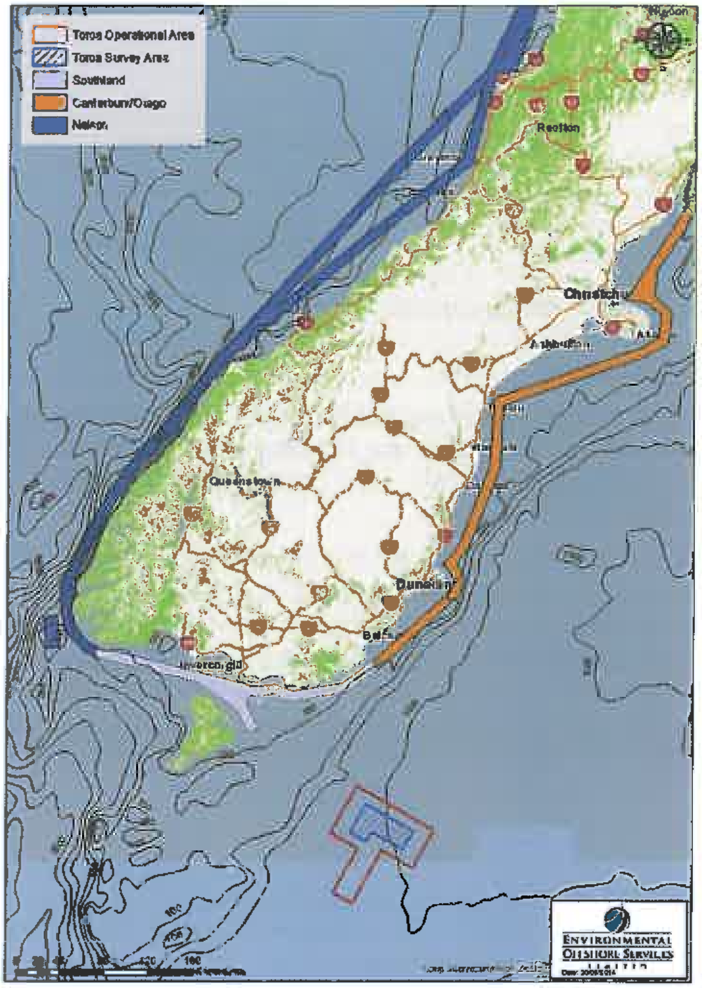


**Figure 41: General Shipping routes surrounding the Toroa Operational Area**

### 4.4.4 Petroleum Exploration

Until recently NZ has had limited exploration outside of the Taranaki Basin, and although the Taranaki Basin remains NZ's premier oil and gas exploration region, other basins have started to attract significant interest as emerging basins of petroleum potential.

Exploration in the Great South Basin started in the early 1970s. Hunt International Petroleum undertook a large seismic acquisition programme and subsequently drilled four wells (Toroa-1, Pakaha-1, Kawau-1A, Hoihoi-1C) in partnership with the NZ government and Philips Petroleum. In 1978, Petrocorp drilled another two sole risk wells (Tara-1 and Takapu-1A). Placid Oil Company took over in 1982 and drilled Rakiura-1 and Pukaki-1 (Figure 42) (NZP&M, 2014b). Since then more seismic acquisition has occurred but no drilling has taken place.

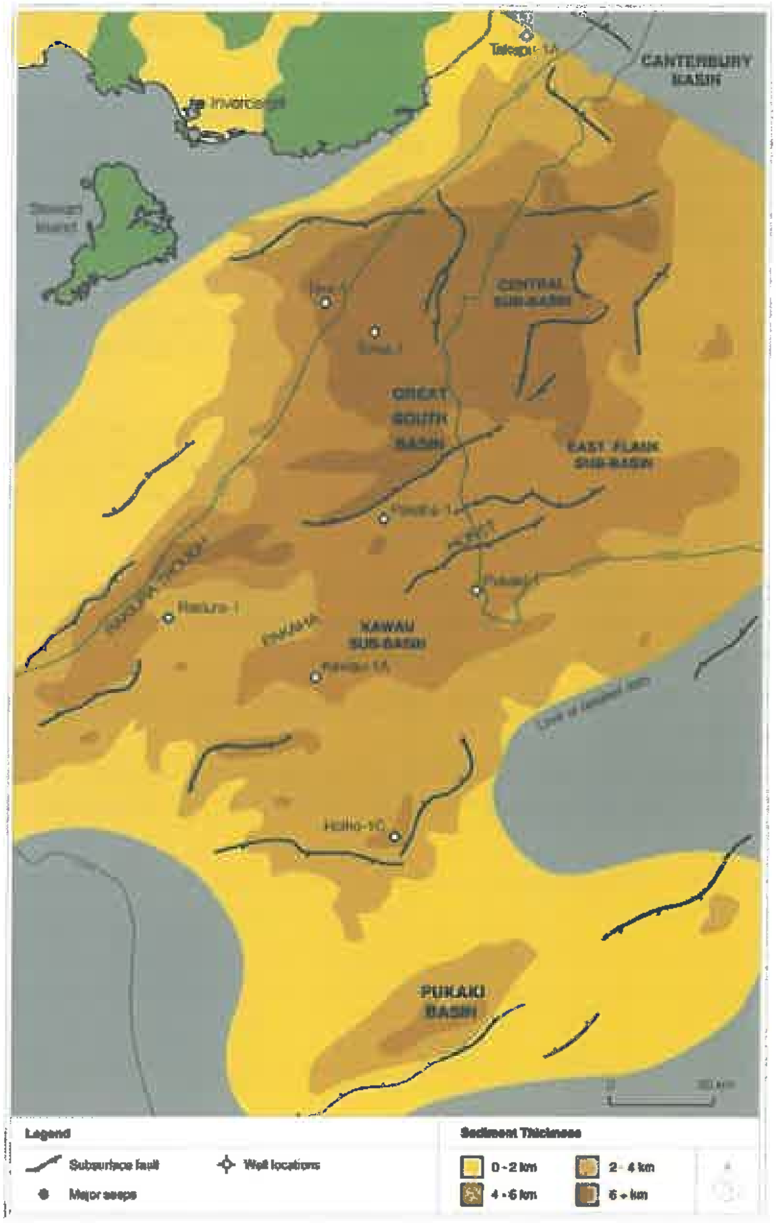


**Figure 42: The Great South Basin (www.nzpam.co.nz)**

# 5 Potential Environmental Effects and Mitigation Measures

This section presents an overview of the potential effects on marine mammals (and the wider marine environment) which may arise from the operation of the Toroa 3D MSS programme.

An Environmental Risk Assessment (ERA) has been undertaken, using a risk matrix to identify the significance of each activity/environmental resource interaction based on a likelihood and consequence approach and provides an important component of this MMIA (Table 14).

A MSS has the potential to lead to environmental effects (e.g. physical disturbance) either under normal operating situations (planned activities) or during an incident (unplanned activities). Marine environmental resources provide ecosystem services that are important to society.

This assessment considers the consequence (Table 15) and likelihood (Table 16) of each potential environmental effect, including its geographical scale (site, local and regional) and its duration. A description of the risk matrix categories is provided in Table 17. A summary of the planned and unplanned activities with the consequence and likelihood scores as well as the overall risk ranking for the Toroa 3D MSS is included in Appendix 6.

The joint Australian & NZ International Standard Risk Management – Principles and Guidelines, (ASNZS ISO 31000:2009) has been used to develop the framework in Table 14. ASNZS ISO 31000:2009 defines risk as 'the uncertainty upon objectives', while the effect is a deviation from the expected – either positive or negative.

The predicted effect in the ERA matrix (Table 14) is based on the assumption that standard mitigation measures to avoid remedy or mitigate environmental effects are in place. The predicted effect of each activity covered in this report is discussed in the following sections.

The main steps used in the ERA can be summarised as follows:

- Identification of the aspects (planned and unplanned) of the marine seismic survey activities that might result in potential effects to marine mammals, marine fauna, the wider marine environment and existing users;
- Identification of the key potential environmental sensitivities vulnerable to those identified activities; and
- Detailed description of each identified potential environmental effect, including the measures which WEL will undertake to control and mitigate each potential effect.

**Table 14: Environmental Risk Assessment**

| | Consequence | 4 - Negligible | 3 - Minor | 2 - Moderate | 1 - Major |
|---|---|---|---|---|---|
| Likelihood Category | 1 - Almost certain | High | High | Extreme | Extreme |
| | 2 - Likely | Medium | Medium | High | Extreme |
| | 3 - Possible | Low | Medium | Medium | High |
| | 4 - Unlikely | Low | Low | Medium | High |

**Table 15: Marine effects – consequence definitions**

| Consequence level[1] | Marine Fauna | Environment & Recovery Period | Natural Environment and Ecosystem functional effects | Proportion of habitat affected | Existing interests (commercial fishers recreational fishers, cultural interests, maritime traffic) |
|---|---|---|---|---|---|
| 1 - Major | Regional medium-term or local long-term impact to communities and populations. Affects recruitment levels of populations or their capacity to increase. | Recovery measured in months up to a year if seismic activities are stopped. Medium scale (10-100 km²). | A major change to ecosystem structure and function with potential for total collapse of some ecosystem processes. Different dynamics now occur with different species or groups now affected. Diversity of most groups is drastically reduced and most ecological functional groups (primary producers etc.) have disappeared. Most ecosystem functions such as carbon cycling, nutrient cycling, flushing and uptake have declined to very low levels. | Activity may result in major changes to ecosystem or region; 60-100% of habitat effected. | Recovery longer term if seismic activities are stopped. Significant change required to the existing interests activities. |
| 2 - Moderate | Local medium-term impact to communities and populations. But long-term recruitment/ dynamics not adversely impacted. | Recovery short term (weeks-months) if activity stopped. Medium scale (1-10 km²). | Ecosystem function altered measurably and some function or components are missing/ declining/ increasing well outside historical acceptable range and/or allowed/ facilitated new species to appear. | Potential adverse effects more widespread; 20-60% of habitat is affected. | Recovery short term if seismic activities are stopped. Existing interests may have to alter their activities as a result of the seismic operations for a short period of time. |
| 3 - Minor | Local short-term impact to communities and populations. Does not threaten viability of community or population. | Rapid recovery would occur if stopped. Localised (<1 km²). Short term (weeks) impact. | Measurable changes to the ecosystem components (biological or physical environment) without there being a major change in function (i.e. no loss of components). Affected species do not play a keystone role - only minor changes in relative abundance of other constituents. | Measurable but localised; potential effects are slightly more widespread; 5-20% of habitat area is affected. | Localised effect and short term impact. Recovery to the existing interest activities would occur if seismic activities stopped. |
| 4 – Negligible | No detectable adverse effects to communities or populations of these species. | Localised effect (immediate area). Temporary impact (days). | Interactions may be occurring but it is unlikely that there would be any change outside of natural variation. No lasting effects. | Measurable but localised, affecting 1-5% of area of original habitat area. | No effect. No negative interactions with existing interests to carry out their normal activities. |

**Table 16: Description of likelihood of environmental risk assessment matrix**

| Level - Descriptor | Likelihood of Exposure |
|---|---|
| 1 - Almost Certain | Will occur many times. Will be continuously experienced unless action is taken to change events. |
| 2 - Likely | Likely to occur 50-99% of the time. Will occur often if events follow normal patterns of process or procedure. |
| 3 - Possible | Uncommon, but possible to occur, for 25-50% of the time. |
| 4 - Unlikely | Unlikely to occur but may occur in for 1-25% of the time. |

**Table 17: Risk matrix categories**

| | | |
|---|---|---|
| | Extreme Risk: (1 – 2) | Significant/fatal impacts to marine mammals, marine fauna, marine environment or existing users of the marine environment. Unacceptable for project to continue under existing circumstances. Requires immediate action and mitigation measures to be implemented, and once implemented will take a relatively long period of time to recover, in some cases not at all. Seismic operations would be shut down. |
| | High Risk: (3 – 4) | Behavioural effects to marine mammals and marine fauna are likely to occur and physical effects may develop closer to the acoustic source. This effect is presumed to be temporary to long-term. Manageable under risk control and mitigation measures to avoid or remedy adverse effects are implemented. A period of time may be required for the behaviour of marine mammals and marine fauna to return to their original state. Requires management decisions to be made on measures to avoid, remedy or mitigate adverse effects for project. Potential shut down of operations until mitigation zones are clear or discussions have been held between DOC and WEL. |
| | Medium Risk: (6 – 9) | Small environmental impact on marine mammals, marine fauna or on marine environment from exposure to the acoustic source or the presence of the seismic vessel and seismic array. No mitigation measures are required for marine mammals, marine fauna or environmental conditions to return to their original behaviour or situation. Potential to cause interruptions to seismic operations. |
| | Low Risk: (12 – 16) | No environmental impact on marine mammals anticipated from operations. No regulatory violation or action anticipated. Seismic operations are acceptable with continued observation and monitoring by the MMO's and PAM operators. No impact on existing interests, marine fauna or the natural marine environment. |

## 5.1 Planned Activities – Potential Effects & Mitigation Measures

### 5.1.1 Physical presence of *Polar Duke* and the Seismic Array

The *Polar Duke* and the associated seismic array have the potential to interfere with a number of commercial, recreational, social, and environmental operations and resources. This potential interference is discussed further in the following sections.

#### *5.1.1.1 Interference with the Fishing Community and Marine Traffic*

There is the potential that the Toroa 3D MSS could interfere with fishing activities due to the length of seismic array towed behind the *Polar Duke*. As a result, fishing vessels (mainly commercial) will be caused a temporary loss or reduction of access to fishing grounds within the Toroa Operational Area during the survey (~35 days).

Commercial fishers who use the general area surrounding the Toroa Operational Area as part of their fishing grounds have been advised of the Toroa 3D MSS and will be contacted closer to commencement with further details. The acquisition of the Toroa 3D MSS could cause temporary displacement of fish stocks; however, most of the commercial fishing within the area is undertaken inshore of the Toroa Operational Area (see Section 4.4.2).

It is assumed that any effect on fisheries is likely to be temporary, and there is unlikely to be any lasting effect on any fish populations.

Trawling is the only method of commercial fishing used within the Toroa Operational Area. It is a mobile method of fishing which leaves no gear deployed on the seabed and as a result will only suffer minor impacts from the Toroa 3D MSS.

To ensure that the potential environmental effects are minimised, WEL will operate 24 hours a day, 7 days a week (weather and marine mammal encounters permitting) to minimise the overall duration of survey; comply with the COLREGS (radio contact, day shapes, navigation lights etc.); have a support vessel present at all times; notify commercial fishers of the Toroa 3D MSS and Toroa Operational Area; issue a Notice to Mariners and a coastal navigation warning, and have a tail buoy attached to the end of each streamer to mark the overall extent of the seismic array and avoid any uncertainty to users of the marine environment.

With the mitigation measures in place, the environmental risk from the Toroa 3D MSS to any fishing, commercial or private vessels is considered to be ***medium***.

#### *5.1.1.2 Interference with Marine Archaeology, Cultural Heritage or Submarine Infrastructure*

The seismic array used for the Toroa 3D MSS will not come into contact with the seabed or coastline inshore of the Toroa Operational Area. The Toroa 3D MSS will use solid streamers with self-recovery devices fitted which release once the streamer reaches a certain depth (~50 m) bringing the streamer back to the surface for retrieval should they be severed and start sinking. In addition, most of the areas that are culturally significant are on the intertidal and shallow subtidal reefs located inshore of the Toroa Operational Area. Consequently, it would only be a rupture to the vessel's fuel tank that could cause these areas to be impacted. WEL have mitigation measures in place to avoid a collision or prevent a spill of fuel to the marine environment. These measures are discussed in Section 5.2.2. Therefore, it is considered that the potential interference with any marine archaeology, cultural heritage or submarine infrastructure arising from the physical presence of the *Polar Duke* and the seismic array during the Toroa 3D MSS is ***low***.

#### *5.1.1.3 Changes in Seabird Behaviour*

Numerous species of seabirds occur in within the Toroa Operational Area (see Section 4.2.7) as a result the chances of encounter of sea birds by the survey vessel is high. Seabirds frequently interact with vessels at sea. Some of these interactions are harmless (i.e. birds using vessels as perching opportunities that would not otherwise be available) and others are negative and can result in injury or death (i.e. collision or entanglement in vessel rigging especially at night).

Research has shown that artificial lighting can cause disorientation in seabirds, although this is mainly true for fledglings and novice flyers, particularly when vessels are operating close to shore (Telfer *et al.*, 1987) and at night. It is believed seabirds use starlight to navigate, hence the potential for artificial lights to interfere with their ability to navigate (Guynup, 2003; Black, 2005).

There are limited scientific data on the reaction of seabirds to MSS operations. A study undertaken in the Wadden Sea (intertidal zone of the North Sea) concluded that bird counts showed no significant deviation in the numbers and seasonal distribution of shorebirds and waterfowl as a result of a seismic survey (Webb & Kempf, 1998). However, temporary avoidance of individual areas of distances up to 1 km was observed due to the activities of the boats and crew.

A number of factors will reduce the potential for any long term interference or damage to seabirds during the Toroa 3D MSS. The *Polar Duke* will always be underway while acquiring the Toroa 3D MSS and any diving birds in close proximity to the acoustic source are unlikely to do so since their prey (baitfish) are likely to have fled the immediate area around the operating acoustic source (see Section 5.1.2.2.2). As a result, the physical presence of the *Polar Duke* and the seismic array during the Toroa 3D MSS is considered to have a ***low*** risk to seabirds.

#### *5.1.1.4 Introduction of Invasive Marine Species*

Ballast water discharges, sea chests and hull fouling on vessels has the potential to introduce and spread marine pests or invasive species to NZ waters.

As part of the environmental management commitments for the proposed Toroa 3D MSS, WEL has committed to manage the risk of introducing Invasive Marine Species (IMS) by requiring that survey vessels are inspected by qualified IMS inspectors. Based on the outcomes of each IMS inspection, management measures will be implemented to ensure vessels meet the Part 2.1 “clean” hull requirement of the recently released Craft Risk Management Standard – Biofouling on Vessels Arriving to NZ.

Therefore, the potential risk of introducing marine pests or IMS as a result of the Toroa 3D MSS is considered ***low***.

#### *5.1.1.5 Interaction of Polar Duke with Marine Mammals*

The physical presence of the *Polar Duke* has the potential to cause disruption to behaviour or even harm marine mammals present within the survey area. The level of potential impact ranges from disruption of behaviour caused by an attraction to the vessel (i.e. wake/bow riding), interruption of sensitive behaviours (i.e. feeding, breeding, resting etc.), to injury and death through ship strike or entanglement in streamers.

It is generally accepted that the presence of a vessel in proximity to marine mammals can cause some disturbance and alteration of behaviour. This is of concern especially in cases of prolonged disturbance of sensitive behaviours such as feeding, breeding and resting. It is possible that the physical presence of the *Polar Duke* could cause some temporary and localised modification in behaviour. However, this disturbance will be very limited in time (given that the vessel will be progressing steadily throughout the Toroa Operational Area only spending limited amounts of time in each area) and space (marine mammals must be in close proximity to the vessel in order to be affected by its physical presence).

A study which considered a total of 292 records of confirmed or possible ship strikes to large whales identified 11 different species as potential ship-strike victims (Jensen & Silber, 2003). Eight of these species are among those which are likely to occur within the Toroa

Operational Area (i.e. blue whale, fin whale, humpback whale, killer whale, minke whale, sei whale, southern right whale, sperm whale). The study highlighted the fin whale (75 records) and the humpback whale (44 records) as the most commonly reported victims of ship strike.

Jensen & Silber (2004) also demonstrated that vessel type plays a role in the likelihood of mortality from any vessel interaction. Out of the 292 fatal strikes considered in the study, vessel type was only known in 134 cases and the majority of these cases were navy vessels and container/cargo ships/freighters. Seismic vessels (described as research) accounted for only one of the 134 known vessel marine mammal strikes.

The vessel's speed is also known to impact the likelihood of mortality from ship strike. Jensen & Silber (2004) report a mean speed of 18.6 kts for vessels involved in lethal ship strike. During acquisition, the *Polar Duke* will only be travelling at ~4.5 kts, less than four times slower than the mean speed reported in the Jensen & Silber (2004) study.

Given the information detailed above, it is considered that the risk to marine mammals arising from the physical presence of the *Polar Duke* and the seismic array during the Toroa 3D MSS is ***low***.

### 5.1.2 Acoustic Source Sound Emissions

As mentioned previously, low frequency sound sources produced in MSSs are directed downwards towards the seafloor and propagate efficiently through the water with little loss due to attenuation (absorption and scattering). Attenuation depends on propagation conditions. In good conditions, background noise levels may not be reached for >100 km; while in poor propagation conditions, background levels can be reached within a few tens of kilometres (McCauley, 1994).

When an acoustic source is activated, most of the emitted energy is low frequency (0.01 – 0.3 kHz), but pulses also contain small amounts of higher frequency energy (0.5 – 1 kHz) (Richardson *et al.*, 1995). The low frequency component of the sound spectrum attenuates slowly while the high frequency sound attenuates rapidly to levels similar to those produced from natural sources.

The acoustic pulse associated with a MSS produces a steep-fronted wave which is transformed into a high-intensity pressure wave (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 pressure decrease and drop in energy. The environmental effects on marine mammals and other fauna associated with MSSs are linked to these sound waves generated from by the acoustic source.

A high intensity external stimulus (the acoustic source emissions in this case) will cause animals to produce an adaptive behavioural response. Depending on the species, this can take the form of displacement, avoidance or flight response, or a change in behaviour type or intensity. The nature (continuous or pulsed), source (visual or auditory) and the intensity of the stimulus, as well as the species, gender, reproductive status, health and age of the animal will impact the length and intensity of the observed response.

These behavioural responses are an instinctive survival mechanism aiming to preserve the organism from any physical or physiological damage. Consequently, animals may suffer temporary or permanent damage in cases when the external stimulus (threat) is too great or the organism is unable to provide sufficient behavioural adaptation (e.g. swim away fast enough) (see Section 5.1.2.3).

Depending on the level of exposure and the sensitivity thresholds of each species, the impact of acoustic emissions ranges from changes in behaviour and related population wide impacts (displacement, surfacing too quickly from deep dives which can result in 'decompression sickness', disruption of feeding, breeding or nursery activities, interference with communication etc.) to physiological effects such as a change in hearing threshold or damage to sensory organs. Indirect effects can also be felt throughout the whole ecosystem with behavioural changes in prey species affecting other species higher up the food chain.

However, the potential behaviour or physiological effects discussed above will be minimised during the Toroa 3D MSS, through the adoption of the Code of Conduct and associated mitigation measures. Adherence to these operational procedures (i.e. MMO's, PAM operators, soft starts, pre-survey observations, mitigation zones) will reduce the risk of marine mammals being exposed to dangerous levels of noise.

More specifically, the requirements and mitigation measures for a Level 1 MSS will be adhered to for the Toroa 3D MSS and the acoustic source will either be shut down or undergo a delayed soft-start if any marine mammals are detected within the relevant mitigation zones. As a result all impacts will be kept to a minimum level.

WEL has undertaken source modelling to ensure the *Polar Duke* is using the appropriate acoustic source volume required to achieve the objectives of the Toroa 3D MSS, while minimising the effects on the marine environment.

The following sections detail the emitted sound levels that will be produced by the Toroa 3D MSS and discuss the predicted potential impacts on marine mammals and other fauna.

##### *5.1.2.1 Sound Transmission Loss Modelling*

WEL commissioned Curtin University to conduct STLM in accordance with the Code of Conduct for undertaking a MSS within an AEI. Acoustic propagation modelling was used to predict received SELs from the Toroa 3D MSS to assess for compliance with the mitigation zones in the Code of Conduct (Appendix 5). The modelling methodology to produce the results summarised below accurately deals with both the horizontal and vertical directionality of the acoustic array and with the different water column and seabed variations in depth and range found throughout the Toroa Operational Area (Galindo-Romero & Duncan, 2014).

The WEL Operational Area spans an area of complex bathymetry (Section 4.1.3) so five different geoacoustic regions representing different bottom substrate types were chosen to represent the probable benthic sediment compositions and sub-bottom layering (Figure 43). The information was obtained from published literature on NZ regional seabed geology and the acoustic properties of marine sediments (Galindo-Romero & Duncan, 2014). The five regions referred to are differentiated by the likely geoacoustic properties of their seabeds and a description is provided below, while the full geoacoustic properties for the regions are defined in Galindo-Romero & Duncan (2014):

- R1:Otago and Southland Shelf (Sand)
- R2: Foveaux Strait (Sand);
- R3: Campbell Plateau & Otago Slope (Silt – Clay);
- R4: Southern shelf – Snares Islands (Carbonate Sediments); and
- R5: Deep water region of Bounty Trough and Western Region (Pelagic Mud - Ooze).

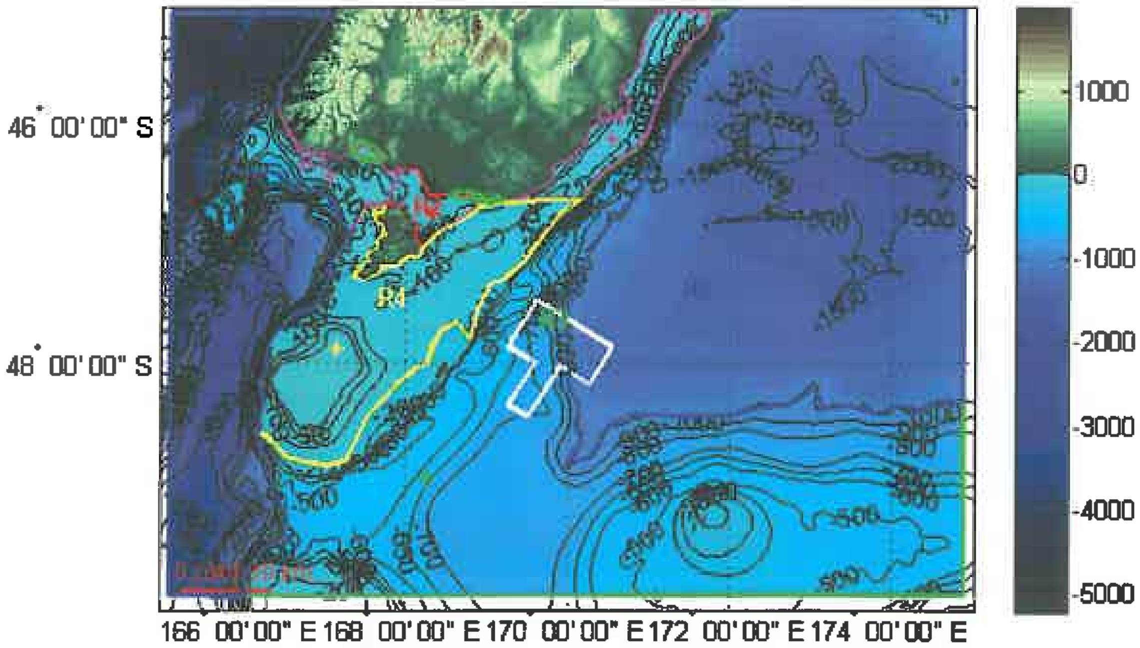


**Figure 43: Geoacoustic regions surrounding the Toroa Operational Area**

The STLM was conducted at one modelling location within the Toroa Operational Area (S1) (Figure 44) and was based on the proposed Toroa 3D MSS acoustic source (3,460 in$^3$). The modelling location was selected based on the greatest potential for sound and energy propagation in a water depth of 630 m. The acoustic source was modelled to be operating 7 m below the sea surface - received sound levels in the water column increase with increasing array depth.

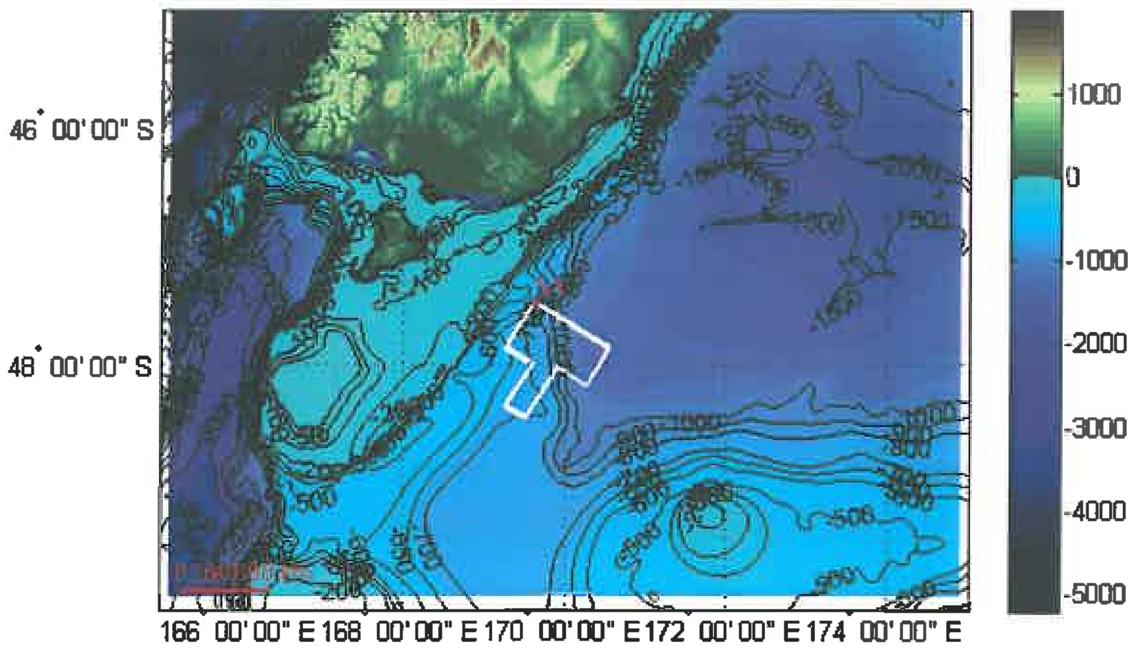


**Figure 44: Modelling location for the Toroa Operational Area (S1)**

##### *5.1.2.1.1 Short range modelling*

The STLM used vertical and horizontal cross-sections through the frequency dependent beam pattern of the array to demonstrate the strong angle and frequency dependence of the sound radiation from the acoustic source array. The horizontal beam pattern shows that in the horizontal plane a large amount of the high frequency energy is radiated in the cross-line direction (90° and 270°) and a significant amount of energy is also radiated in the in-line direction (azimuths of 0° and 180°) as a result of the acoustic source configuration (Figure 45). These beam patterns are characteristic of an acoustic array with wide spacing between elements or in the case of the Toroa 3D MSS, wide spacing between the sub-arrays.

Figure 45 indicates the maximum received SELs at location S1 within the Toroa Operational Area. The mitigation zones within the Code of Conduct are shown in Figure 45 and are indicated by a solid black circle (200 m), dashed black circle (1.0 km) and dash-dot black circle (1.5 km) relative to the maximum received SELs.

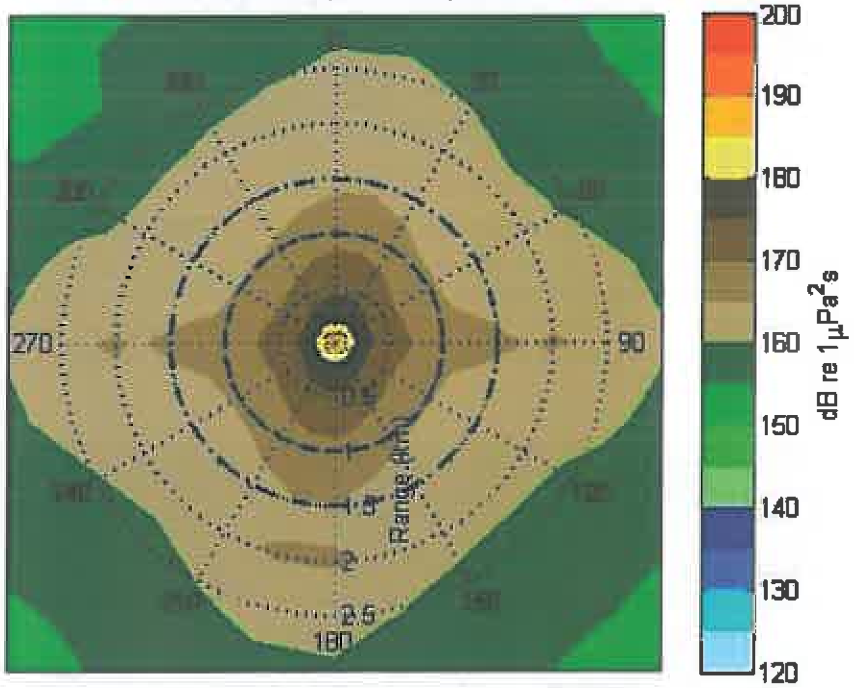


**Figure 45: Maximum received SELs at any depth from the *Polar Duke* 3,460 in³ acoustic source at S1**

The modelling conducted in by Galindo-Romero & Duncan (2014) indicates that 100% of SELs lie below the threshold of 186 dB re 1 μPa².s (injury criteria) at distances of 200 m or greater from the source and below 171 dB re 1 μPa².s (behaviour criteria) at distances equal or above 1,000 m from the source (Table 18).

**Table 18: Maximum SELs as a function of range from source location S1 in the Toroa Operational Area**

| Range (m) | Maximum Sound Exposure Level (re 1 μPa² s) |
|---|---|
| 200 | 180.8 |
| 1,000 | 168.7 |
| 1,500 | 165.7 |

An assessment was undertaken to determine the percentage of received SELs below the standard thresholds within the Code of Conduct as a function of range. The percentage levels are plotted in Figure 46. These results show that 100% of SELs will be below 171 dB re 1 μPa$^2$.s and 186 dB re 1 μPa$^2$.s at the relevant mitigations distances.

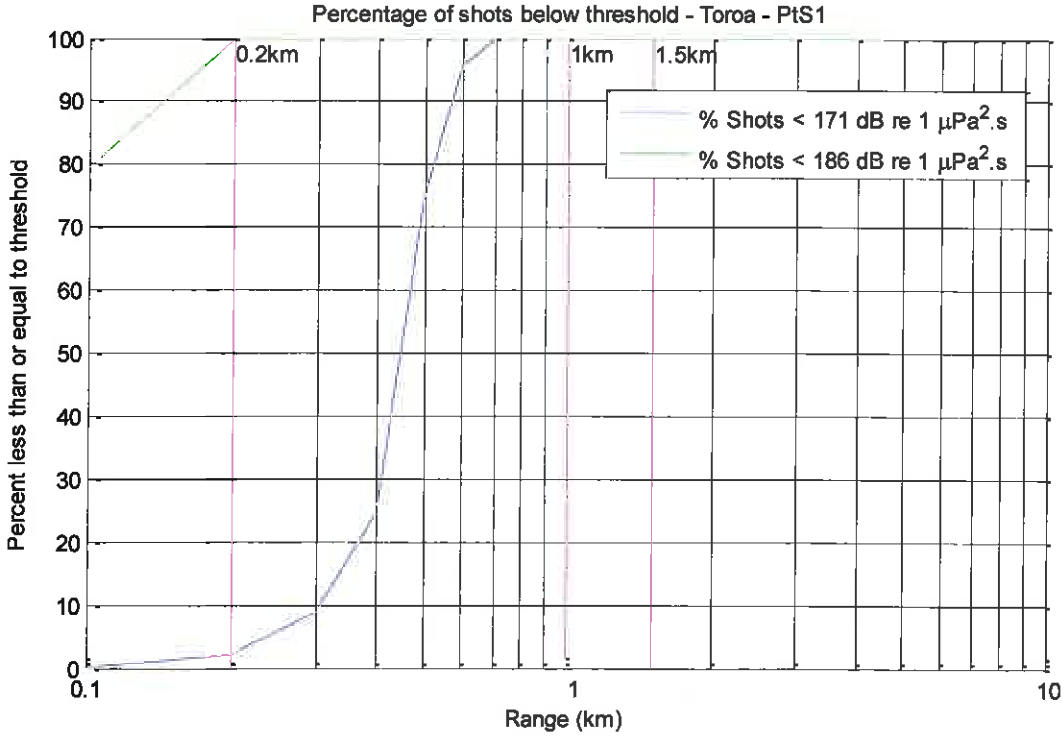


**Figure 46: Percentage of received SELs below thresholds of 186 dB re 1 μPa$^2$.s (green) and 171 dB re 1 μPa$^2$.s (blue) as a function of range for source S1. Percentages are calculated over all azimuths and depths**

#### *5.1.2.1.2 Long Range Modelling*

Long range modelling was undertaken at S1 out to a 300 km radius (Figure 47), with the S1 location being selected on the assumption that it was the location most likely to produce the highest SELs inshore of the Toroa Operational Area and within the Catlins Coast MMS. WEL have taken a conservative approach for the long range modelling, as the source location was selected to model worst case, where in reality the acoustic source will not be operating at full capacity at this location during the Toroa 3D MSS.

For long range modelling, variations in topography, such as the presence of canyons, are automatically accounted for by the inclusion of the bathymetry along propagation path. There are some limitations to the accuracy of this approach; however, the inshore portion of the Toroa Operational Area has variable bathymetry upslope which causes rapid attenuation as the sound travels into inshore waters. In contrast, short range modelling procedure precludes taking variations in topography into account; but such variations would be expected to have minimal impact on predicted sound levels at the 200 m, 1 km and 1.5 km mitigation zones specified in the Code of Conduct.

The acoustic propagation modelling method used for the long range modelling is usually referred to as N x 2D because it involves running a two-dimensional (range-depth) model along multiple azimuths. This is a common method of acoustic propagation modelling and is usually of more than adequate accuracy; however, its accuracy is limited by ignoring out of plane effects and will be reduced in situations where the bathymetry is very steep and sound is propagating almost parallel to the contours. Several research groups are experimenting with fully three-dimensional parabolic equation models but these have not yet reached a point of efficiency and maturity where they can be used for operational modelling.

The long range STLM results shown in Figure 47 identify the strong and complicated directionality of the SELs due to a combination of the directionality of the acoustic array which produces the maximum amount of radiated energy in the cross-line direction and also due to the effects of bathymetry and seafloor composition. The effect of variable bathymetry causes rapid attenuation upslope from the source, and also the change from a silt-clay layered bottom to a carbonate sediment halfspace with high attenuation (Galindo-Romero & Duncan, 2014). The propagation is enhanced downslope, in the inline direction to deeper waters, as this is also one of the main directions of energy propagation with this array. As sound levels travel downslope, direction rays are flattened on each subsequent seabed reflection, reducing the number of seabed interactions and therefore attenuation rate. A reduction in sound speed with increasing depth results in downward refraction, where the highest sound levels occur in the lower portion of the water column. For sound travelling upslope from the acoustic source, the rays steepen on each subsequent seabed reflection, increasing the attenuation rate and distributing the sound energy more evenly through the water column.

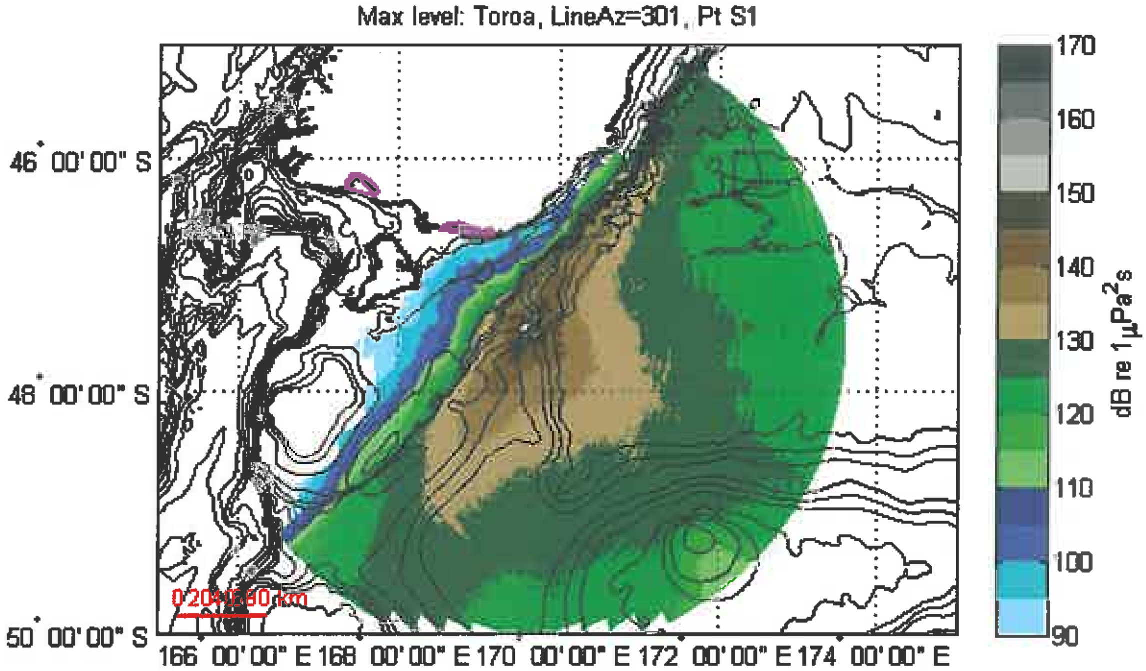


**Figure 47: Geographical distribution of long range modelled SELs to a maximum range of 300 km at S1. Survey line azimuth is 301°T**

This is illustrated in Figure 48 which shows a vertical cross-section through the sound field in the in-line direction (along 120 °T and 300 °T) produced by the long-range modelling at S1 within the Toroa Operational Area. This cross-section shows the SEL emitted from the array to the shore and into deep water (Galindo-Romero & Duncan, 2014). The highest SELs are transmitted vertically downward and absorbed into the seabed; however, due to the total volume and frequency dependent beam pattern of the acoustic source array, energy is trapped in the ocean interior with some refraction in the southwest direction (Galindo-Romero & Duncan, 2014). The left hand side of the plot towards the northwest shows the SELs predicted to reach the Catlins Coast MMS.

Figure 49 shows a second vertical cross-section through the sound field produced in the cross-line direction (30 °T and 210 °T) by an acoustic source at S1. Similar to the in-line direction the highest levels are transmitted vertically downwards into the seabed and sound is attenuated rapidly inshore (right hand side of the plot – southeast) and extends over the continental shelf (left hand side of the plot – northwest).

As part of the STLM to assess what SELs could potentially reach the Catlins Coast MMS, WEL took a conservative approach as part of the STLM, including modelling at the location likely to create the highest SELs and using water column parameters for the autumn sound speed profile to capture worst-case conditions that could be encountered towards the end of the Toroa 3D MSS. The STLM indicated that the maximum SELs at the offshore Catlins Coast MMS boundary was predicted to be lower than 90 dB re 1 μPa$^2$.s which is well below the 171 dB re 1 μPa$^2$.s threshold within the Code of Conduct and equivalent to ambient levels (DOC, 2013).

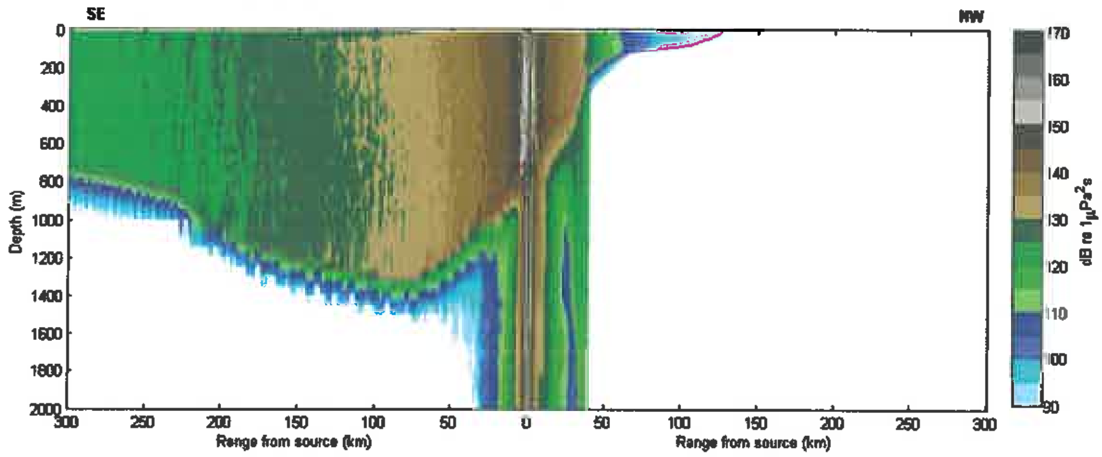


**Figure 48: Vertical cross-section through the sound field in the in-line direction (120°T and 300°T), centred on S1. The magenta line is the seabed.**

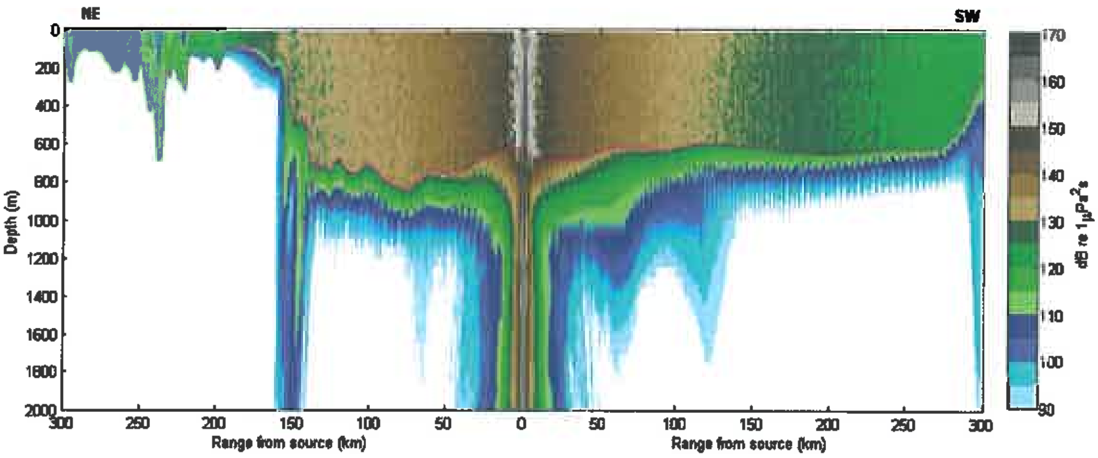


**Figure 49: Vertical cross-section through the sound field in the cross-line direction (30°T and 210°T), centred on S1. The magenta line is the seabed.**

### *5.1.2.2 Behavioural effects on marine mammals and fauna*

#### *5.1.2.2.1 Avoidance and changes in distribution*

The implications of movement or displacement of individual animals or a population depend on the temporal nature of the displacement. Short-term movement out of an area is thought to have very limited or no long term implications for a population. In contrast, long-term avoidance of an area could lead to displacement into sub-optimal or high-risk habitats resulting in additional exposure to predators as well as the loss of foraging or mating opportunities and therefore severely impacting the population.

Additionally, any changes in abundance and distribution of prey species (fish) will have a wide effect both on their predators (i.e. seabirds, marine mammals, fish etc.) and potentially also on fishing activities (both commercial and recreational).

#### 5.1.2.2.1.1 Fish

Overall, studies of the impact of seismic surveys on fish can be separated into two main categories: experiments during which caged fish are exposed to an acoustic source and studies which rely on field data such as catch-effort data in an area before and after a seismic survey. Particular caution must be exercised when interpreting (and potentially extrapolating) results from existing peer-reviewed and grey literature on the impact of seismic source emission on fish. Variability in the characteristics of the experimental design (source properties, line spacing, timescale and spatial extent of data collection etc.) and the subjects (wild or farmed, demersal or pelagic, migrant or site-attached, age etc.) make it difficult to draw overall conclusions. Furthermore, tank behavioural studies only provide information on the very short term reaction of fish during and immediately after the onset of noise (Popper & Hastings, 2009). Beyond this, all behaviour is biased by the fact that the subjects are constrained to the tank and unable to flee.

The studies on the behavioural effects of acoustic sources on fish reviewed for this report gave little indication of long-term behavioural disruption. Short term responses in fish include C-starts and startle responses (Pearson *et al.*, 1992; Wardle *et al.*, 2001; Hassel *et al.*, 2004; Boeger *et al.*, 2006); modifications in schooling patterns and swim speed (Pearson *et al.*, 1992; McCauley *et al.*, 2000; Fewtrell & McCauley, 2012); freezing (Sverdrup *et al.*, 1994); and changes in fish distribution in water column (Pearson *et al.*, 1992; Fewtrell & McCauley, 2012)tr. Furthermore, habituation and a resulting decrease in startle response has been documented in fish (Hassel *et al.*, 2004). This is also likely to occur during the Toroa 3D MSS due to the use of soft-starts and the fact that the survey vessel will be moving slowly through the survey area. Overall, there is little indication of disturbance of the "day-to-day" behaviour of the animals (Wardle *et al.*, 2001; Woodside Petroleum Ltd, 2007a).

As mentioned above, MSS acquisition has been noted to cause both vertical and horizontal displacement in fish away from the acoustic source (Pearson *et al.*, 1992; McCauley *et al.*, 2000; Woodside Petroleum Ltd, 2007a; Colman *et al.*, 2008; Handegard *et al.*, 2013). Fish which have a pelagic lifestyle (rockfish, cod, haddock, blue whiting) tend to dive deeper (McCauley *et al.*, 2000), whereas site-attached coral reef species have been observed to swim into the reef for shelter on approach of the seismic survey and to resume normal activity swiftly after the vessel has passed (Woodside Petroleum Ltd, 2007a; Colman *et al.*, 2008).

It has long been considered by commercial fishers that MSSs can be disruptive to their fishing operations, and this is a view widely held around the world (McCauley *et al.*, 2000). Additionally, a number of studies have demonstrated a reduction in catch per unit effort in close proximity to MSSs (Skalski *et al.*, 1992; Engas *et al.*, 1996; Bendell, 2011; Handegard *et al.*, 2013). In an unpublished review (Gausland, 2003), the results of the Engas *et al.* (1996) study were contested based on the fact that natural fluctuations in fish stocks had not been taken into consideration and that a long term negative trend could explain the reduction in catch rate. Additionally, although these studies have documented an effect on catch rates, these have only been short term investigations (up to five days after the exposure to the seismic source in the case of Engas *et al.* (1996) and no evidence of long term displacement was noted.

In the North Sea, geophysical surveys have been conducted continually over the last 40 years and during recent years MSS vessels have operated on fishing grounds in the Norwegian and Barents Seas. Bendell (2011) considered long-line catches off the coast of Norway during the acquisition of a two week seismic survey with a peak source level of 238 dB re 1µPa@1m. The study showed that catch rates reduced by 55-80% within the survey area and for a distance up to 5 km. However, once the MSS ceased, catch rates returned to normal within 24 hours (Bendell, 2011).

In Lyme Bay (UK), the distribution of bass was documented during a seismic survey using a peak source of 202 dB re 1µPa@1m over a period of three and a half months. No long term changes in distribution where noted and importantly, data from tagged fish demonstrated that there were no large scale emigrations from the survey area (Pickett *et al.*, 1994).

In the Adriatic Sea, no changes in pelagic biomass where observed following emissions from an acoustic source with a peak of 210 dB re 1µPa@1m which indicates that catch rates would also remain unaffected (Labella *et al.*, 1996).

In the Faroes, a large scale study of catch rates was undertaken based on fishing vessel logbooks. Despite a majority of fishers reporting a decrease in catch caused by seismic surveys, the analysis of logbook records showed no significant effect of seismic activity in the area (Jakupsstovu *et al.*, 2001).

Based on these findings, it is likely that fish will undertake avoidance behaviour resulting in the displacement of stocks within the Toroa Operational Area. Crucially, this displacement is predicted to be temporary and of an extent which falls within the normal geographic range of each particular species (Bendell, 2011). Short term repercussions include a possible increase in fishing effort if fishing is harder and a displacement of predator species/disruption of feeding activities (see Section 5.1.2.2.2). However, it is most likely that commercial fishing vessels would avoid the Toroa Operational Area for the 30 day MSS duration and due to the distance offshore no recreational fishing boats will fish within the Toroa Operational Area.

Given the potential for displacement or avoidance of fish stocks to occur, it is considered that the risk to fish stocks and their natural habitat preferences in close proximity to the *Polar Duke* within the Toroa Operational Area is ***medium***.

In order to keep impact to a minimum, mitigation measures will be implemented. The Toroa 3D MSS will operate 24 hours a day, 7 days a week (weather and marine mammal encounters permitting) to ensure the survey period will be as short as possible (~35 days).

Commercial fishers who use the Toroa Operational Area as part of their fishing grounds have been advised of the Toroa 3D MSS and will be contacted closer to commencement with further details.

#### 5.1.2.2.1.2 Crustaceans

As in the case of fish, behavioural responses of crustaceans to acoustic sources has the potential to impact their availability for capture by predator species and fishing operations. Although literature on the subject is limited, there is no indication of an effect of this nature on these species.

The most well-known crustacean species with NZ is the red rock lobster (*Jasus edwardsii*). Red rock lobster are found in coastal waters around NZ where rocky subtidal reefs are present. They are an important species within NZ from a commercial, cultural and recreational perspective. The Toroa Operational Area lies within commercial Cray Fishing Area 8 (CRA 8) although the statistical areas for quota management only extend out to the CMA. CRA 8 is the largest mainland fishery geographically and has a Total Allowable Commercial Catch (TACC) of 962 tonnes which allows 29 tonnes for recreational catch and 30 tonnes for customary take.

Catch rates of three species of shrimp (southern white shrimp, southern brown shrimp and Atlantic seabob) showed no variation as a result of a seismic survey with a peak emission of 196 dB re 1 µPa at 1 m, indicating no short term effect on these species (Andriguetto-Filho *et al.*, 2005). Similarly, no effect was detected in an extensive review of catch data from a lobster fishery spanning 25 years during which 28 2D and five 3D MSSs had been acquired (Parry & Gason, 2006). In this study, the number of seismic pulses was correlated to catch per unit effort data over 12 depth stratified regions (0-50 m, 51-100 m, 101-150 m) in the Western Rock Lobster Zone (Western Victoria, Australia). Catch per unit effort data showed no significant change in the weeks and years following seismic surveys leading authors to conclude a lack of apparent impact on rock lobster fisheries.

As a result, the impact of the acoustic source on these species is deemed to be **low**.

#### 5.1.2.2.1.3 Cephalopods

Situated in the food chain between fish and marine mammals, cephalopods are key bio-indicators for balance in vast and complex marine ecosystems (Andre *et al.*, 2011). Both squid and octopus occur in waters surrounding or inshore of the Toroa Operational Area. Octopus live a cryptic lifestyle around reef structures and generally closer to shore in waters shallower than 200 m. Squid can be found from coastal waters up to the edge of the continental shelf (Figure 39). They are a very short-lived but fast growing species which only live for one year and spawn in May and July (MPI, 2014a).

Although startle responses have been observed in caged cephalopods exposed to acoustic sources, studies addressing noise-induced morphological changes in these species have been limited (Andre *et al.*, 2011).

In the McCauley *et al.* (2000) study, squid showed avoidance of the acoustic source by keeping close to the water's surface at the cage end furthest away from the acoustic source, at the surface where a sound shadow of almost 12 dB re 1 µPa exists. While alarm responses were consistent above 151-161 dB re 1 µPa, ramp-up of the acoustic source was seen to decrease startle response in these animals (McCauley *et al.*, 2000).

A later study corroborated these findings and further demonstrated that a source level of 147 dB re 1 µPa was necessary to induce an avoidance reaction in squid. Throughout this experiment, other reactions were also observed including alarm responses (inking and jetting away from the source), increased swimming speed and aggressive behaviour. It was noted that the reaction of the animals decreased with repeated exposure to the sound suggesting either habituation or impaired hearing (Fewtrell & McCauley, 2012).

As mentioned previously, it is not straightforward to use caged studies such as these as indicative of real world situations. However, it can be concluded that cephalopods will exhibit some form of avoidance response to the acoustic source.

Based on the information detailed above, the risk of the acoustic emissions from the Toroa 3D MSS on cephalopod species is considered to be ***low***.

#### 5.1.2.2.1.4 Marine Mammals and other Megafauna

Marine mammals are widely believed to stay away or avoid operating acoustic sources used during MSS (Goold, 1996; Stone & Tasker, 2006; Thompson *et al.*, 2013). These responses vary between species. In a large scale review of the impact of 201 seismic surveys conducted across the UK, researchers found that odontocetes were more likely to show lateral response (within the limits of visual observations), killer whales and mysticetes generally demonstrated a more limited movement sufficient to increase distance to the acoustic source, long-finned pilot whales simply changed their orientation, whereas as sperm whales showed no reaction.

In cases where avoidance has been observed, marine mammals have recorded swimming away from an acoustic source with some observed instances of rapid surface swimming and breaching (McCauley *et al.*, 1998; McCauley *et al.*, 2003a). This behaviour has been interpreted as a way of reducing their exposure to the higher sound levels.

Depending on the species considered, the level of sound needed to initiate a behavioural response can vary. Humpback whales exposed to seismic surveys, consistently changed course and speed to avoid any close encounters with an operating seismic array. In the

McCauley *et al.* (2003a) study, the SPLs which initiated this avoidance response was estimated at 160 – 170 dB re 1 µPa peak to peak.

Harbour porpoises exposed to a 470 in$^3$ acoustic source array over ranges of 5 – 10 km, at received peak-to-peak sound pressure levels of 165-175 dB re 1 µPa and SELs of 145 – 151 dB re 1µPas$^{-1}$ were temporarily displaced. However, the animals were typically detected again at affected sites a few hours after the exposure. Moreover, the level of response declined throughout the 10 day survey period (Thompson *et al.*, 2013). Thompson *et al.* (2013) concluded that prolonged seismic surveys did not lead to broad-scale displacement of marine mammals and that impact assessments should focus on sub-lethal effects of the acoustic emissions. It should, however, be highlighted that the acoustic source used for the Thompson *et al.* (2013) study was far smaller than the source to be used in the Toroa 3D MSS. It is surmised that the potential implication of this in the Toroa 3D Operational Area will be the displacement of animals over a larger distance and for a longer period.

As mentioned above (see Section 4.2.4), both resident and migratory or vagrant species are expected to be encountered within the Toroa Operational Area. Although it would appear that displacement of animals is only temporary, it is important to consider the implications on large scale patterns such as migrations. During the proposed Toroa MSS there are no migrations expected through the Toroa Operational Area. McCauley *et al.* (2003a) did not detect any changes in migratory patterns caused by seismic survey and it is therefore considered that with no migrations expected during the Toroa MSS this can also be applied to the Toroa Operational Area through the adherence to the Code of Conduct and associated mitigation measures.

Patterns of avoidance have also been observed in other species of megafauna. A study which exposed captive sea turtles to an approaching acoustic source indicated that they display a general alarm response at ~2 km from the acoustic source with avoidance behaviour estimated to occur at 1 km.

In addition to these avoidance responses, there is also anecdotal evidence of marine mammals being attracted to the seismic vessel and acoustic source. Common dolphins have been known to repeatedly head towards an operating seismic vessel to bow ride as it entered shallow waters off the Taranaki coastline with an active source. There are also multiple records of pinnipeds approaching an active acoustic source running at full capacity, suggesting that their inquisitive nature may override any fright or discomfort these animals may experience. A desktop study focussing on pinniped behaviour around an operating seismic vessels is currently being finalised. The report has drawn data from all of the MMO reports in NZ waters and any interactions or behavioural responses observed and recorded for NZ fur seals around the seismic vessel. The results from this study are expected at some stage in 2014.

Based on the studies mentioned above, it is surmised that displacement of marine mammals will occur. However, given the mobile nature of the survey, the disturbance will only be temporary. Despite the noted instances where marine mammals have been attracted to seismic survey vessels, it is considered that acoustic emissions from the Toroa 3D MSS have a ***medium*** risk to marine mammals and megafauna due to potential avoidance and displacement from the Toroa Operational Area.

Mitigation measures against this type of impact on marine mammals include the adherence to the Code of Conduct and mitigation measures. In addition, the survey will be operating outside of migration seasons in order to keep the number of marine mammals impacted to a minimum (see Section 4.2.4.2).

#### *5.1.2.2.2 Disruption to Feeding Activities*

The potential disruption to feeding activities caused by the acoustic emissions of the Toroa 3D MSS is linked to the displacement of prey species (see Section 5.1.2.2) and the displacement of the predators themselves away from feeding grounds (see Section

5.1.2.2.1.4). Either scenario could have effects which are felt throughout the food chain and lead to the cessation of feeding activities for a more or less prolonged period.

Seabird feeding activities are likely to be interrupted through both these mechanisms. Birds in the area could be alarmed as the seismic array passes in their vicinity, causing them to stop feeding (Macduff-Duncan & Davies, 1995). Additionally, the displacement of baitfish could lead to a reduction in the diving activity of birds.

Similarly, marine mammals could be forced to leave feeding grounds (e.g. large aggregations of krill or fish) as a result of the Toroa 3D MSS acoustic emissions. A number of species are known to feed in and around the Toroa Operational Area (see Section 4.2.4). As mentioned earlier (see Section 5.1.2.2.1.4), marine mammals tend to temporarily avoid areas in which a MSS is occurring. This deviation from their natural distribution could have an impact on their ability to capture prey easily, forcing them to temporarily expend more energy hunting food. Data on the potential offshore marine mammal feeding grounds is scarce and any sightings recorded during the Toroa 3D MSS will greatly enhance the knowledge of marine mammal distribution in the area.

Once the seismic vessel and acoustic array has passed through an area, or once the Toroa 3D MSS is complete, the sound level within the marine environment will dissipate and there will be no further environmental effects on any species residing there. Therefore, the potential disruption and disturbance to marine mammals feeding activities by the Toroa 3D MSS acoustic source within or in areas adjacent to the Toroa Operational Area is considered to be ***medium.***

Mitigation measures to prevent disruption to the feeding mechanisms of marine mammals include the adherence to the Code of Conduct and mitigation measures listed within this MMIA.

Once the Toroa 3D MSS is complete, any resonant noise within the Toroa Operational Area or surrounding marine environment would diminish allowing animals to return to their preferred habitat.

#### *5.1.2.2.3 Modification of Reproductive Behaviour in Marine Mammals*

Since there is potential for the acoustic source emissions of the *Polar Duke* to cause displacement of marine mammals, it should also be concluded that the acoustic source emissions have the potential to interrupt sensitive behaviour such as mating, breeding and nursery activities. However, since no confirmed breeding or mating grounds have been identified within the Toroa Operational Area the risk of impact on reproductive behaviour is limited to the encounter of travelling or feeding mother and calf pairs. This scenario is widely covered in the Code of Conduct which defines larger exclusion zones around the acoustic sources when a Species of Concern with calf is sighted. It is assumed that encounters of this type will not be sufficiently numerous to have any population wide impact.

Although it is fairly likely that a cetacean mother and calf pair will be encountered during the survey (see Table 8), the measures imposed by the Code of Conduct are such that the overall risk to marine mammals reproductive behaviour is considered to be ***medium***.

#### *5.1.2.2.4 Interference with Acoustic Communication Signals in Marine Mammals*

Marine mammals use sound both actively and passively for foraging, navigation, communication, reproduction, parental care, avoidance of predators and overall awareness of the environment (Thomas *et al.*, 1992; Johnson *et al.*, 2009). Consequently, the ability to perceive biologically important sound is crucial to these animals. Any acoustic disturbance caused by a MSS emitting sound in the same frequency range as these biological signals (Table 19) could interfere with, or even obscure, sounds emitted by individual animals and potentially lead to significant environmental effects (Richardson *et al.*, 1995; Di Iorio & Clark, 2009). Adaptive responses to anthropogenic sound such as changes in vocalisation strength, frequency, and timing have been documented in numerous studies (McCauley *et al.*, 1998; Lesage *et al.*, 1999; McCauley *et al.*, 2003a; Nowacek *et al.*, 2007; Di Iorio & Clark, 2009; Parks *et al.*, 2011).

**Table 19: Cetaceans communication and echolocation frequencies**

| Species | Communication Frequency (kHz) | Echolocation Frequency (kHz) |
|---|---|---|
| Bottlenose dolphin | 0.8 – 24 | 40 – 130 |
| Common dolphin | 0.2 – 16 | 23 – 67 |
| Killer whale | 0.5 – 25 | 12 – 25 |
| Long finned pilot whale | 1 – 18 | 6 – 117 |
| Sperm whale | 0.1 – 30 | 2 – 30 |
| Blue whale | 0.0124– 0.9 | N/A |
| Hector's dolphin | N/A | 120-125 |
| Fin whale | 0.017 - 0.15 | N/A |
| Humpback whale | 0.025 - 4 | N/A |
| Minke whale | 0.06 - 0.85 | N/A |
| Southern right whale | 0.05 - 0.5 | N/A |
| Sei whale | 1.5 - 3.5 | N/A |
| Beaked whales | 25 – 50 | 16 |
| Northern bottlenose whale | 3 - 16 | 20 - 30 |
| Dusky dolphin | N/A | 30-130 |
| Risso's dolphin | 22.5 - 90 | N/A |
| Pygymy sperm whale | 90-150 | N/A |

As mentioned in Section 3.1, sound frequencies emitted by seismic acoustic sources are broadband, where most of the energy is concentrated between 0.01 kHz and 0.25 kHz.

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

- Low frequency cetaceans which have an auditory bandwidth of 0.007 kHz and 22 kHz

  Species from this group which could be found inside and in the area surrounding the Toroa Operational Area include (see Section 4.2.4.1): southern right whale, pygmy right whale, humpback whale, minke whale, sei whale, blue whale and fin whale.

- Mid-frequency cetaceans which have an auditory bandwidth of 0.15 kHz and 160 kHz

  Species from this group which could be found inside the Toroa Operational Area include (see Section 4.2.4.1): bottlenose dolphin, striped dolphin, common dolphin, dusky dolphin, southern right whale dolphin, Risso's dolphin, false killer whale, hourglass dolphin, killer whale, long finned-pilot whale, sperm whale, Arnoux's beaked whale, Shepherd's beaked whale, southern bottlenose whale, Cuvier's beaked whale, Andrew's beaked whale, Hector's beaked whale, Blainville's beaked whale, Gray's beaked whale, strap-toothed beaked whale, pygmy beaked whale and True's beaked whale.

- High-frequency cetaceans which have an auditory bandwidth of 0.2 kHz and 180 kHz

  Species from this group which could be found inside the Toroa Operational Area include the pygmy sperm whale (see Section 4.2.4.1).

The greatest potential for interference of a MSS with cetacean acoustic signals is at the highest end of the seismic spectrum and the lowest end of whales and dolphins communication spectrum (Table 19).

The low frequency cetaceans (mysticetes) are particularly affected since they have the most overlap with the frequencies of seismic survey acoustic sources (Figure 50).

It has been shown that blue whales will increase their calls (emitted during social encounters and feeding) when a MSS is operational in the area (Di Iorio & Clark, 2009). It is believed that this occurs in order to increase the probability that communication signals will be successfully received by conspecifics and compensate for the masking of communications by noise.

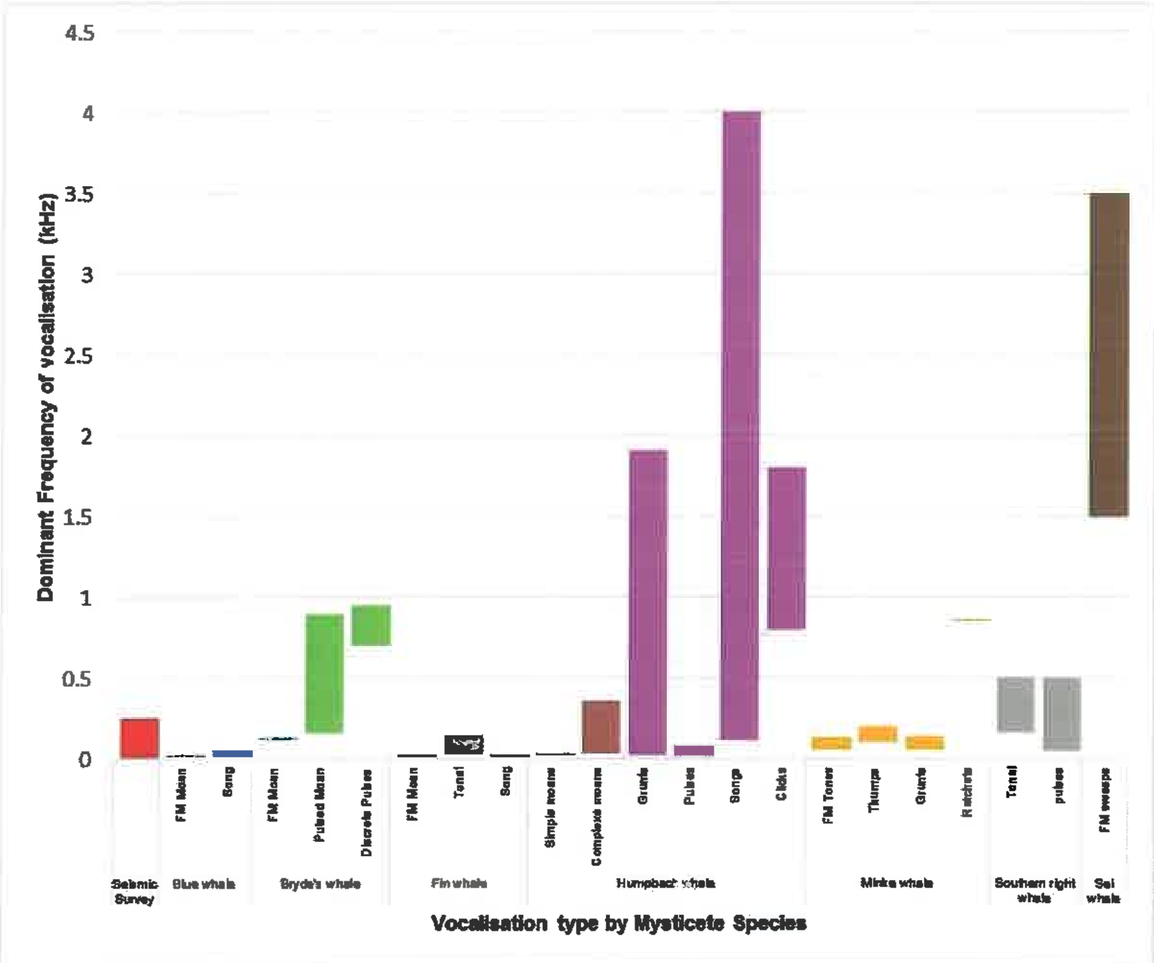


**Figure 50: Dominant frequencies of vocalisations produced by mysticete species likely to occur in Toroa Operational Area and overlap with MSS acoustic emissions**

Mid and high frequency cetaceans are not likely to be detrimentally affected, as they generally operate at frequencies far higher than those generated by seismic acoustic sources (Table 19).

From the reviewed studies and available literature it is considered that there are no resident cetacean populations or critical habitat within the Toroa Operational Area, so any potential impact on transiting cetaceans and the nature of these impacts would be temporary. It is considered that the acoustic source emission from the Toroa 3D MSS could have a ***medium*** risk to marine mammal's use of naturally produced acoustic signals.

#### *5.1.2.3 Physiological Effects on Marine Fauna*

##### *5.1.2.3.1 Larvae*

Early larval stages of fish and invertebrates generally have a pelagic lifestyle. It is in this phase of their life cycle that the larvae could be exposed to noise if a MSS is being conducted in close proximity. Studies have shown that mortality of plankton communities can occur if they are within 5 m of an active acoustic source (Payne, 2004; DIR, 2007).

In a study of stage II zoeal Dungeness crab, no significant effect in terms of survival or time of moult was detected in individuals exposed to acoustic source (peak 231 dB re 1 µPa).

A study conducted in NZ at the Leigh Marine Laboratory exposed scallop larvae (*Pecten novaezelandiae*) to seismic pulses in tanks to assess the effect of noise on the early development stages of scallop larvae (Aguilar de Soto *et al.*, 2013). Scallop larvae were placed in noise flasks in a thin plastic mesh and suspended at a depth of 1 m in a tank filled with seawater (2 m diameter and 1.3 m deep). The noise flasks were suspended 5-10 cm in front of a sound transducer emitting a pulse every 3 seconds. Noise exposure started immediately after the flasks were put into the tank, which was within one hour after fertilisation. Control samples were also used with no acoustic source present. A total of 4,881 scallop larvae were utilised in the study and were sampled at seven fixed intervals (24, 30, 42, 54, 66, 78, and 90 hours) in order to document the development through several larval stages.

At completion of the Aguilar de Soto *et al.* (2013) study, 46% of the noise-exposed larvae showed abnormalities in the form of malformations including localised bulges in the soft body of the larvae, but not in the shell. In the control tanks, no malformations were found.

The study concluded that the observed damage was related to particle motion rather than the pressure component of the noise exposure. Recordings within the tank showed that the sound levels within the tank during the experiment were 160 dB re 1 µPa at 1m, but the particle velocities experienced by the larvae resulted in far-field pressure levels of 195-200 dB re 1 µPa. The report further concluded that given the strong disruption of larval development, weaker but still significant effects could be expected at lower exposure levels and shorter exposure durations.

These results are the first evidence that continual sound exposure can cause growth abnormalities in larvae and it is assumed that the exposure results of Aguilar de Soto *et al.* (2013) could be applied to other shellfish and fish in early developmental stages.

However, these results must be treated with caution when applying them to industry standard MSSs. The Aguilar de Soto *et al.* (2013) study, considers newly fertilised larvae, exposed to high intensity sounds with a short shotpoint interval (3 seconds) for an extended duration (between 24 and 90 hours). In contrast, industrial standard MSS apply a shotpoint interval of 8-11 seconds and exposure time is much shorter since the source is constantly moving at speed of 4.5 kts. Furthermore, the Aguilar de Soto *et al.* (2013) study used a pulse duration of 1.5 seconds whereas the pulse duration for a seismic array is approximately 30 milliseconds. Additionally, given that the Toroa 3D MSS will be operating approximately 115 km off the southern coastline, it is unlikely that recently fertilised shellfish larvae will be affected a, as fertilisation generally takes place in coastal waters.

Due to the distance offshore, the continual movement of the vessel, and the widespread and seasonal nature of larval production, the population level risk to fish and shellfish larvae is considered to be ***low***.

##### *5.1.2.3.2 Fish*

The potential physiological impact of sound on fish is variable. Depending on the source level and species considered, it can take the form of increased stress levels (Santulli *et al.*, 1999;

Smith, 2004; Buscaino *et al.*, 2010), temporary or permanent hearing threshold shifts (Smith, 2004; Popper *et al.*, 2005), or damage to sensory organs (McCauley *et al.*, 2003b).

Studies undertaken on fathead minnows (*Pimephales promelus*) have shown that a threshold shift in hearing is directly correlated to the frequency and duration of sound exposure (Scholik & Yan, 2002). Temporary threshold shift (less than 24 hours) was observed after one hour of exposure to white noise at >1 kHz, but no threshold shift occurred at 0.8 kHz. The frequency of the acoustic sound for the Toroa 3D MSS is between 2 – 250 Hz, and the sound emissions will only occur every 8 seconds during acquisition.

Another study in which northern pike (*Esox lucius*), broad whitefish (*Coregonus nasus*) and lake chub (*Couesius plumbeus*) were exposed to a 730 in$^3$ acoustic source (significantly smaller than the Toroa 3D MSS acoustic source) found varying degrees of threshold shift, but recovery occurred within 24 hours of exposure (Popper *et al.*, 2005).

These experimental results should be considered in conjunction with results of behavioural studies (see Section 5.1.2.2.1.1) which demonstrate that fish will generally move away from a loud acoustic source in order to minimise their exposure. Consequently these data can be interpreted as a "worst case scenario" for fish which remain in close proximity to the seismic source. Additionally, even in close proximity to the source, not all species will be affected in the same manner. When considering three species of fish exposed to received levels of 193 dB re 1 µPa, Popper *et al.* (2005) found that two species experienced a temporary threshold shift while the third showed no impact whatsoever.

In 2006, WEL applied to the regulator in Australia (Environmental Protection Authority) to undertake the 340 km$^2$ Maxima 3D MSS around Scott Reef in Western Australia. Prior to the survey an extensive scientific field validation survey costing over $10 million was conducted to assess the effects of a seismic survey on coral reef fish and coral species. The experiment involved 123 people from a variety of scientific organisations, including the Australian Institute of Marine Science, who conducted pre-, during and post seismic survey field experiments. The Maxima MSS Area water depths ranged from 20 – 1,100 m with the scientific study taking place within the southern lagoonal waters of Scott Reef. The study involved the exposure of faunal communities to acoustic source emissions using the actual survey vessel and acoustic array (2,005 in$^3$) to be used in the Maxima MSS. The monitoring work consisted of shallow water fish diversity and abundance data collection, coral monitoring, deep-water fish diversity and abundance data collection, collection of fish samples for pathology studies, and physiological studies. Sub-surface equipment was also deployed including sound loggers, remote underwater video and fish exposure cages with captured reef fish. The key finding of these studies was that there was no temporary or permanent hearing threshold shift in any species after exposure to the acoustic source and, crucially, that there were no long term impacts on fish populations (Woodside Petroleum Ltd, 2007b; Colman *et al.*, 2008).

It has been concluded that during the Toroa 3D MSS there is potential for the acoustic source to induce temporary effects on fish species that are in close proximity to the acoustic source, but the risk of any lasting physiological effects resulting in population level consequences on fish species caused by the acoustic source emissions during the Toroa 3D MSS are considered to be ***low***.

#### *5.1.2.3.3 Crustaceans and Molluscs*

There is currently little information on how marine organisms process and analyse sound, which makes assessments of the impacts of artificial sound sources in the marine environment difficult (Andre & Kamminga, 2000). Research has shown that the effects of noise produced by a MSS on macroinvertebrates (scallop, sea urchin, mussels, periwinkles, crustaceans, shrimp, gastropods) result in very little mortality below sound levels of 220 dB re 1µPa@1m, while some show no mortality at 230 dB re 1µPa@1m (Royal Society of

Canada, 2004). Sound levels required to cause mortality, based on the STLM would only be reached in very close proximity to the acoustic source (Andre *et al.*, 2011).

Moriyasu *et al.* (2004) undertook a literature review of studies on the effects of noise on invertebrate species. One study used a single acoustic source with source levels of 220-240 dB re 1 µPa on mussels and amphipods at distances of 0.5 m or greater. Results showed there were no discernible effects on the mussels or amphipods as a result of the acoustic sound at these short distances. A study in the Wadden Sea exposed brown shrimp to a sub-array of 15 acoustic sources with a source level of 190 dB re 1 µPa at 1 m from the source in a water depth of 2 m and found no mortality of the shrimp or any evidence of reduced catch rates. This result was attributed to the absence of gas-filled organs in these species.

From the summary above and based on the fact that the Toroa 3D MSS will be conducted in waters greater than 600 m in depth, it is considered that the Toroa 3D MSS would have ***low*** physiological effects on marine benthos.

##### *5.1.2.3.4 Cephalopods*

Situated in the food chain between fish and marine mammals, cephalopods are key bio-indicators for balance in vast and complex marine ecosystems (Andre *et al.*, 2011). Squid live in waters surrounding the Toroa Operational Area, while octopus can be found in inshore coastal waters where they live a cryptic lifestyle around reef structures. Squid are a very short-lived but fast growing species which only live for one year and spawn in May and July (MPI, 2014a).

It is believed that if cephalopods are in close proximity (<1.5-2 km) to the operating acoustic source there is the potential for trauma to these species (Andre *et al.*, 2011).

The chances of octopus being within 1.5-2 km from the acoustic source is low given the Toroa 3D MSS will be conducted in water depths of greater than 600 m and the closest point to land of the Toroa 3D MSS is approximately 115 km.

Given their pelagic lifestyle, there is a chance that squid could come within 1.5-2 km of the acoustic source resulting in potential physical damage. However, squid are generally short-lived but fast growing species with high fecundity rates which spawn between May and July (MPI, 2014g). As a result, there is not anticipated to be any overall significant effects on the squid populations off the southeast coast of NZ.

In Andre *et al.* (2011), four cephalopod species were exposed to low frequency sounds (50-400 Hz sinusoidal wave sweeps with a 1 second sweep period for two hours). The study identified the presence of lesions in the statocysts, which are believed to be involved in sound reception and perception. The received sound levels from these waves were of 157 ± 5 dB re 1 µPa, with peak levels at 175 re 1 µPa. It was therefore concluded that the effects of low frequency noise for a long period of time could induce severe acoustic trauma to cephalopods (Andre *et al.*, 2011).

Based on the information detailed above, the mobile nature of the seismic survey, the wide distribution of pelagic cephalopod species and high population turn-over, the risk of the acoustic emissions of the Toroa 3D MSS on cephalopod species is considered to be ***low***.

##### *5.1.2.3.5 Marine Mammals*

Sound intensities that would result in physiological effects are largely unknown for most marine animals, with current knowledge based on a limited number of experiments (Richardson *et al.*, 1995; Gordon *et al.*, 2003). Marine mammals are a protected species so they cannot be sacrificed for physical examinations and the size of most marine mammals does not generally allow captive studies to occur. However, it is believed that to cause immediate serious physiological damage to marine mammals, SELs need to be very high (Richardson *et al.*, 1995) and these are only found close to the acoustic source. STLM showed that the SELs for injury criteria for cetaceans, are likely less than 150 m from the source of the modelling location S1 which was derived for a water depth of 630 m. SEL thresholds relating to injury of cetaceans are expected at much closer distances to the source based on the thresholds outlined by Southall *et al.* (2007).

Elevated SELs can lead to a hearing threshold shift, which in most cases is believed to only be temporary, while exposure to an extreme SEL could cause a permanent threshold shift.

In adherence to the Code of Conduct, pre-start observations, soft start and shut-down procedures will help minimise the risk to marine mammals to as low as reasonably practicable (ALARP) during the Toroa 3D MSS. It should, however, be noted that most free-swimming marine mammals have been observed to swim away from an acoustic sound well before they are inside the range within which any physiological effects could occur (see Section 5.1.2.2.1.4).

Based on the information above, it is considered that the acoustic source emissions during the Toroa 3D MSS could have ***medium*** physiological effects on marine mammals in close proximity to the *Polar Duke*.

#### *5.1.2.3.6 Birds*

Acoustic damage to birds could arise if one was to dive in very close proximity to the acoustic source while it was active. Although there is potential for some birds to be alarmed as the seismic array passes by them, any effects are likely to be beyond any harmful range (Macduff-Duncan & Davies, 1995). Additionally, once the acoustic source is operating, it is not likely that birds will be in the water close to the array.

Movement of baitfish away from an operating acoustic source means that there will be very little feeding by birds in close proximity to the acoustic source and therefore the risk to seabirds is ***low***.

#### *5.1.2.3.7 Deepwater Benthic Communities*

The potential effects of sound on benthic communities such as deepwater corals are not well understood and there is a notable lack of literature on the topic. It has been suggested that sound emissions from seismic sources could either remove or damage polyps on the coral calcium carbonate skeleton, or potentially impact the larval stages of the coral in the same way that larval stages of fish and invertebrates can be affected (see Section 5.1.2.3.1).

The Woodside Petroluem Ltd (2007) study was significant as it detected no signs of lethal or sub-lethal effects of a seismic survey on warm water corals in shallow water. This study was the world's first scientific study of this kind and demonstrated that MSSs can be undertaken in sensitive coral reef environments with no detrimental impact (Colman *et al.*, 2008). In addition, a study of hard coral communities within the southern lagoon of Scott Reef (45-60 m depth) considering condition of the reef 'before' and 'after' seismic survey, indicates no impact (Heyward *et al.*,in prep).

Based on the Woodside Petroluem Ltd (2007) study and given that there are no scientific publications of this type available for deepwater corals, it is also assumed that there would be no detectable effects on any of the deepwater coral species present in waters surrounding the Toroa Operational Area. These deepwater corals (e.g. black coral) are generally found at depths of >200 m (except in Fiordland) and so at a sufficient distance from the acoustic source to be unharmed by its emissions.

It is thought that deepwater corals' reproductive strategy could also mitigate against the potential impact of seismic sources. Mortality of pelagic or planktonic coral larvae is known to occur if the acoustic source is within close range (< 5 m) (DIR, 2007). This type of close interaction between the source and larvae is highly improbable for black coral. Despite having very low levels of fecundity and recruitment (making them vulnerable to any mortality), black coral are assumed to be protected from any close contact with the acoustic sources by the fact that their larvae are negatively buoyant and do not disperse very far from the mature coral (Parker *et al.*, 1997; Consalvey *et al.*, 2006).

Given that the larvae are negatively buoyant and that black coral generally live a great depths (>200 m – apart from Fiordland) there is very little chance that the larval stages will not come in close proximity to the acoustic source used during the Toroa 3D MSS. As a result, it is considered that the acoustic emissions from the Toroa 3D MSS will pose a ***low*** risk to the deepwater corals.

### 5.1.3 Solid and Liquid Wastes

During the Toroa 3D MSS various types of waste will be produced (sewage, galley waste, garbage and oily water) and if inappropriate management occurred there is the potential for an environmental effect. Each type of waste requires correct handling and disposal; the volume of waste generated will depend on the number of crew onboard each vessel and the MSS duration. All wastes that are produced during the Toroa 3D MSS will be controlled in accordance to WEL standard practice and international standards.

#### *5.1.3.1 Generation of Sewage and Greywater*

The liquid wastes that will be generated during the Toroa 3D MSS will include sewage and greywater (wastewater from washrooms, the galley and laundry). The *Polar Duke* and *Sanco Sky* have onboard sewage treatment plants which ensure a high level of treatment before the waste is discharged. All vessels involved in the Toroa 3D MSS also have an International Sewage Pollution Prevention Certificate (ISPPC) where applicable to vessel class.

As a result of the high level of treatment, the sewage generated by the vessels involved in the Toroa 3D MSS receives, it is considered that the risk to the marine environment is ***low***.

#### *5.1.3.2 Generation of Galley Waste and Garbage*

In accordance with the NZ Marine Protection Rules, only biodegradable galley waste, mainly food scraps, will be discharged to sea at distances greater than 12 Nm from the nearest land. Comminuted waste (<25 mm) can be discharged beyond 3 Nm from shore. Given the high energy offshore marine environment, these discharges will rapidly dilute to non-detectable levels very quickly. All solid and non-biodegradable liquid wastes will be retained onboard for disposal to managed facilities ashore through the waste management contractor.

For all disposal options MARPOL Annex V stipulations will be followed with records kept detailing quantity, type and approved disposal route of all wastes generated and will be available for inspection. All wastes returned to shore (including hazardous waste) will be disposed of in strict adherence to local waste management requirements with all chain of custody records retained by WEL.

As a result of these operating procedures and adherence to MARPOL, the risk from galley waste and garbage to the marine environment is considered to be ***low***.

#### *5.1.3.3 Generation of Oily Waters*

Oily waters on any vessel are generally derived from the bilges. The *Polar Duke* has a bilge water treatment plant that achieves a discharge that is below the NZ and MARPOL requirements of 15 ppm.

All vessels involved in the Toroa 3D MSS have approved International Oil Pollution Prevention Certificates (IOPPC) where applicable to vessel class and have a Shipboard Oil Pollution Emergency Plan (SOPEP) in place.

As a result of operating in compliance to the above procedures, the environmental risk of any discharges to the marine environment is considered to be ***low***.

##### *5.1.3.4 Atmospheric Emissions*

Exhaust gasses from the *Polar Duke's* engines, machinery and air compressor generators are the principle sources of air emissions (combusted exhaust gasses) likely to be emitted to the atmosphere. Most of these gaseous emissions will be in the form of carbon dioxide, although smaller quantities of other gasses (oxides of nitrogen, carbon monoxide and sulphur dioxide) may be emitted. The *Polar Duke* has an International Air Pollution Prevention Certificate (IAPPC) where applicable to vessel class which ensures that all engines and equipment are regularly serviced and maintained. Low sulphur fuel is also used by the *Polar Duke* which will further reduce emissions.

Potential adverse effects from these emissions are related to the reduction in ambient air quality in populated areas and potential adverse effects/health effects on personnel. However, given the distance offshore and exposed nature of the Toroa Operational Area and the anticipated low level of emissions, the environmental risk arising from the Toroa 3D MSS is considered to be ***low***.

## 5.2 Unplanned Activities – Potential Effects & Mitigation Measures

Unplanned activities are rare during MSS operations; however if they were to occur, they would likely be a result of a streamer break or loss, fuel/oil spill or a vessel collision. All marine operations have some risk, no matter how low and this assessment has covered the potential of this occurring.

### 5.2.1 Streamer Break or Loss

The potential damage to a seismic acquisition streamer could result from snagging with floating debris; or rupture from abrasions, shark bites or other vessels crossing the streamer.

The acquisition streamers to be used in the Toroa 3D MSS are solid streamers. Therefore, if an acquisition streamer was to break or be severed, there is little potential for an effect on the marine environment. The solid acquisition streamers are negatively buoyant and require movement to maintain depth so if a streamer was severed it would start sinking. The streamers have Self Recovery Devices (SRD) fitted which deploy for retrieval once the streamer sinks below approximately 50 m depth. This will prevent any potential for crushing or damage to the benthic communities.

The Toroa 3D MSS will be undertaken by experienced personnel and as a result of the streamer type to be used for the Toroa 3D MSS, if a streamer was severed or lost the environmental risk would be ***low***.

### 5.2.2 Hydrocarbon Spills

The potential for a fuel or oil spill during the Toroa 3D MSS could arise during an accidental spill during refuelling operations, leaking equipment or storage containers, or hull/fuel tank failure due to a collision or sinking. An accidental spill from the refuelling or hydrocarbon spills caused by a collision or sinking are the most likely to cause an environmental effect. Other types of spills would be generally be contained on the vessel.

If a spill from the *Polar Duke'* fuel tank did occur, the maximum possible volume spilt would be 244 $m^3$. However, for this to occur, there would have to be a complete failure of the vessel's fuel containment system or catastrophic hull integrity failure. The high-tech navigational systems onboard, adherence of the COLREGS and operational procedures to international best practice will ensure that these risks are kept to a minimum.

All vessels involved in the Toroa 3D MSS have an approved and certified SOPEP and IOPPC where applicable to vessel class (as per MARPOL 73/78 and the Maritime Protection Rules Part 130A and 123A) which are onboard the vessels at all times. In addition, the *Polar*

*Duke* has a HSE Management Plan and Emergency Response Plan which would be used in the event of any emergency, including fuel spills.

Refuelling will be undertaken at sea every three weeks from the support vessel accompanying the *Polar Duke*. The *Polar Duke* has a detailed refuelling protocol and procedures in place which are designed to prevent any incidents during a refuelling process. Spills caused by fuel handling mishaps are rare due to tried-and-true monitoring and management systems and procedures for such activities. Potential causes for a spill during refuelling could include hose rupture, coupling failures or tank overflow.

During refuelling operational procedures and equipment will be in place and implemented on board the seismic and support vessels and will be subject to the following Woodside requirements:

- Refuelling is only undertaken during daylight and when sea conditions are appropriate as determined by the vessel master;
- Job hazard analysis (or equivalent) is undertaken in place and reviewed before each fuel transfer;
- Transfer hoses are fitted with 'dry-break' couplings (or similar and checked for integrity);
- Spill response kits are maintained and located in close proximity to hydrocarbon bunkering areas to use to contain and recover deck spills;
- Bunkering operations will be manned with constant visual monitoring of gauges, hoses and fittings and sea surface; and
- Radio communications will be maintained between seismic and support vessel.

Should a spill occur during a refuelling operation, a spill response will initially be undertaken in accordance with the *Polar Duke* and support vessels SOPEPs. Notifications will be provided to Maritime NZ as per the requirements of the HSE Management Plan and Emergency Response Plan onboard the *Polar Duke*.

However, due to the safety, environmental and maritime requirements that will be implemented throughout the Toroa 3D MSS, the risk of a fuel or oil spill occurring is considered to be ***low***.

### 5.2.3 Vessel Collision or Sinking

If a collision occurred whilst the *Polar Duke* was at sea, the biggest threat to the environmental would be the vessel reaching the sea floor and the subsequent release of any hazardous substances, fuel, oil or lubricants. However, this is very unlikely as the risks are mitigated through the constant presence of a support vessel and adherence to the COLREGS. As a result, the risk for a vessel collision or sinking is considered to be ***low***.

## 5.3 Mitigation Measures

WEL will adhere to the mitigation measures identified in the Code of Conduct for operating a Level 1 MSS to minimise any adverse effects to marine mammals from the MSS operation (DOC, 2013a). While undertaking the Toroa 3D MSS, if there are any instances of non-compliance to the Code of Conduct and the mitigation measures identified below, the Director-General will be notified immediately.

The operational procedures that WEL will follow will be detailed in the MMMP (<u>Appendix 4</u>) and circulated among the MMOs and crew, with a summary of these operating procedures and mitigation measures listed in the following sections.

### 5.3.1 2013 Code of Conduct Mitigation Measures

The 2013 Code of Conduct was updated following the 2012 – 2013 summer period during which several MSSs were conducted in the Taranaki Basin, with operators voluntarily adhering to the 2012 Code of Conduct. During these surveys, a number of operational issues were identified and led to the review of the 2012 Code of Conduct before the next MSS season (2013 – 2014 summer period). For the Toroa 3D MSS, the requisite mitigation measures specific to a Level 1 MSS are identified in Section 2.3.1. However, WEL will implement additional mitigation measures and these are discussed in Section 5.3.2.

### 5.3.2 Additional Mitigation Measures for the Toroa 3D MSS

#### *5.3.2.1 Sound Transmission Loss Modelling*

As discussed in Section 5.1.2.1 STLM has been undertaken to predict SEL's at the mitigation zones stipulated within the Code of Conduct and correlates to distances from the *Polar Duke* during the Toroa 3D MSS. The STLM was based on the specific configuration of the acoustic source to be used for the Toroa 3D MSS and the environmental conditions (i.e. bathymetry, substrate and underlying geology) of the Toroa Operational Area.

Results were used to validate the mitigation zones identified for a Level 1 MSS in the Code of Conduct and as a result the the STLM results were within the thresholds stated in the Code of Conduct. For MSSs undertaken in an AEI, the Code of Conduct requires that the STLM should provide the relative distances from the acoustic source at which behavioural criteria (171 dB re 1μ$Pa^2$-s SEL) and injury criteria (186 dB re 1μ$Pa^2$-s SEL) could be expected. The STLM results showed that the SEL's produced from the Toroa 3D MSS will be below the behaviour and injury criteria thresholds within the Code of Conduct.

As per the requirements in Appendix 1 of the Code of Conduct, the STLM will be validated during the Toroa 3D MSS and the results will be provided to DOC. Representative data recorded on the seismic streamers during the seismic survey will be used to compare actual water column sound exposure levels with pre-survey modelled predictions. These results will be verified to ensure the mitigation zones are appropriate.

#### *5.3.2.2 Additional marine mammal observations outside Toroa Operational Area*

The *Polar Duke* will travel to the Toroa Operational Area following completion of the Toroa 3D MSS in the Taranaki Basin. On transit to the Toroa Operational Area, a MMO will be on the bridge to observe for any marine mammals thus contributing to the understanding and distribution data of marine mammals around NZ.

Any marine mammal observations outside the Toroa Operational Area will be recorded in the 'Off Survey' forms developed by DOC.

#### *5.3.2.3 Necropsy on stranded marine mammals*

If any marine mammals are stranded or washed ashore during or within two weeks after the Toroa 3D MSS and inshore of the Toroa Operational Area, a discussion between DOC and WEL will occur to determine where the seismic vessel had been operating and whether a necropsy will be undertaken. DOC will be responsible for all aspects of the necropsy and coordination with pathologists at Massey University in order to determine the cause of death and whether it was a result of any pressure-related or auditory injuries. WEL will consider covering the costs directly associated with Massey University undertaking a necropsy.

#### *5.3.2.4 Notification of any marine mammal carcass observed at sea*

If a marine mammal carcass is observed at sea during the Toroa 3D MSS, the location and species (where possible) and any other useful information will be recorded and the lead MMO will notify and provide this information to DOC at the earliest opportunity.

## 5.4 Cumulative Effects

Anthropogenic activities such as shipping and fishing occurring in the offshore Southern waters contribute to an increased level of underwater noise. The cumulative effect of shipping and seismic survey noise was investigated in the Di Iorio & Clark (2009) study and it was concluded in that study that shipping noise did not account for any changes in the acoustic behaviour of blue whales. Given the location of the Toroa Operational Area of the southeast coast of NZ and the lack of maritime shipping within the Toroa Operational Area (Figure 40), noise from shipping traffic has not been considered in this cumulative effects assessment.

At the time of preparation of this MMIA and through consultation with DOC National Office, there are likely to be two other MSSs being undertaken around the Toroa Operatioal Area.

When SEL's from two different seismic surveys combine it is actually counter-intuitive; the largest difference between the combined and individual SEL's will be 3 dB re 1µP$^2$s, and this will only occur at locations where both surveys produce the same SEL's.

In other words, if at a given location, Survey A by itself would produce a SEL of 160 dB re 1µP$^2$s, and Survey B by itself would also produce an SEL of 160 dB re 1µP$^2$s, then the two surveys combined will produce an SEL at the same location of 163 dB re 1µP2s (Alec Duncan pers. comm.).

However, if one survey produces a higher SEL than the other survey, then the higher SEL will dominate to the point where if Survey A produces a SEL of 6 dB re 1µP$^2$s higher than Survey B, then the combined level is 1 dB re 1µP$^2$s higher than the higher of the individual SEL (Survey A). This combination of SEL's for two seismic sources operating is shown in Figure 51.

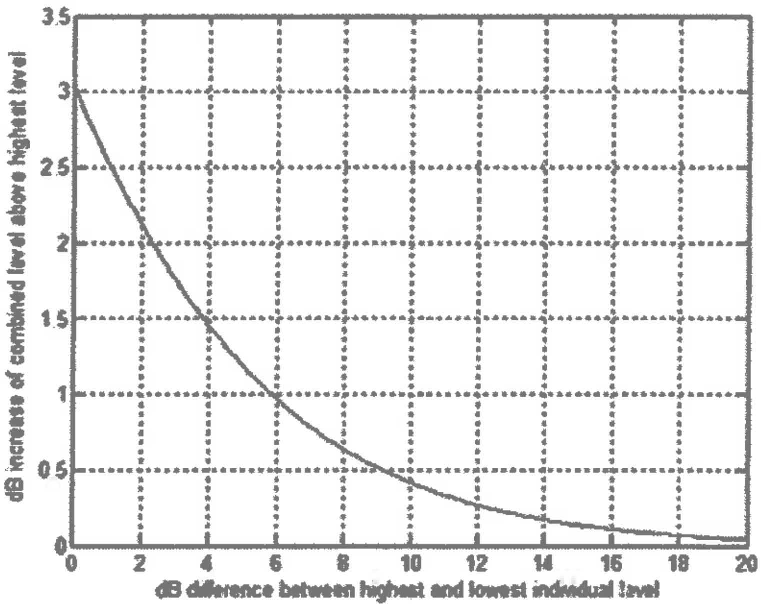


**Figure 51: Sound exposure when two seismic sources operate together**

The STLM shows that 100% of the SELs are below 171 dB re 1µP$^2$s at 1,000 m from the source. When the Toroa 3D MSS and the other MSS are operating at the same time, they will likely be many km's apart. The distance between the survey areas will reduce the potential for any cumulative effects.

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

The potential for cumulative impacts are also more likely to be related to physical features such as depth, bathymetry and coastline shape. A higher risk is present in shallow waters and enclosed bays or areas, whereas open coastline allows the sound to dissipate more rapidly and therefore the risk is lower. Resident populations (i.e. Hector's dolphins) are going to be more sensitive to cumulative impacts than for migratory or non-resident populations (i.e. humpback whales). Given the Toroa 3D MSS is approximately 120 km away from the coastline, the likelihood that any marine mammals residing in close proximity to the Toroa Operational Area will be impacted by cumulative impacts from the MSS's is low.

Therefore, given the operators will ensure there is a significant distance between any MSS running concurrently due to large Operational Areas and with the mitigation measures in place; the potential cumulative effects on marine mammals, marine fauna or the marine environment from the Toroa 3D MSS will be ***low***.

## 5.5 Summary of Environmental Effects and Mitigation Measures

The potential environmental effects and associated mitigation measures that will be implemented for the Toroa 3D MSS as identified in this MMIA are summarised in Table 20. WEL will operate in accordance to the Code of Conduct and implement mitigation measures to ensure any potential effects from the Toroa 3D MSS are to ALARP.

**Table 20: Toroa 3D MSS planned and unplanned activities and the potential effects and mitigation measures to be implemented**

| Aspect or Source | Potential Environmental Effect | Likelihood of Occurrence | Consequence of Occurrence | Proposed Mitigation Measures to Avoid, Remedy or Mitigate Environmental Effects | Risk Category Ranking |
|---|---|---|---|---|---|
| | | | Planned activities | | |
| Physical presence of *Polar Duke*, acoustic array and streamer. | Interference with the fishing community and marine traffic. | Possible | Minor | 24/7 operations to minimise overall duration of MSS.<br>Compliance with COLREGS.<br>Support vessel present at all times.<br>Notification to commercial fishing companies and representatives.<br>Notification to sportfishing clubs.<br>Notice to mariners issued. | Medium |
| | Interference with marine archaeology, cultural heritage or submarine infrastructure. | Unlikely | Negligible | Solid streamer with SRD.<br>Compliance with COLREGS.<br>Support vessel present at all times. | Low |
| | Changes in seabird behaviour. | Negligible | Negligible | No mitigation options available.<br>MMOs will record any seabird strikes with the vessel that are witnessed. | Low |
| | Introduction of invasive marine species. | Negligible | Minor | WEL's IMS standards.<br>Adherence to Import Health Standard for ballast water exchange.<br>Adherence to Craft Risk Management Strategy for biofouling. | Low |
| | Interaction with marine mammals. | Possible | Negligible | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Low |
| Acoustic sound source emissions – behavioural effects | Changes in abundance or behaviour of fish | Possible | Minor | 24/7 operations to minimise overall duration of Toroa 3D MSS.<br>Soft-start procedures.<br>Acoustic source and vessel always moving at approximately 4.5 knots.<br>Any exposure will only be temporary | Medium |
| | Avoidance and startle responses in marine mammals and other marine megafauna | Possible | Minor | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Medium |
| | Disruption to feeding activities. | Possible | Minor | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Medium |

| Aspect or Source | Potential Environmental Effect | Likelihood of Occurrence | Consequence of Occurrence | Proposed Mitigation Measures to Avoid, Remedy or Mitigate Environmental Effects | Risk Category Ranking |
|---|---|---|---|---|---|
| | | | | | |
| | Disruption of reproductive behaviour in marine mammals | Unlikely | Minor | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Low |
| | Interference with acoustic communication signals. | Possible | Minor | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Medium |
| Acoustic sound source emissions – physiological effects | Physiological effects on marine mammals | Possible | Minor | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of MSS.<br>STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. | Medium |
| | Physiological effects on seabirds | Unlikely | Negligible | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS. | Low |
| | Physiological effects on fish | Unlikely | Minor | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS. | Low |
| Acoustic sound source emissions – physiological effects on invertebrates | Physiological effects on larvae | Unlikely | Minor | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS.<br>Survey Area is located 115 km from shore. | Low |
| | Physiological effects on benthos | Unlikely | Minor | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS.<br>Survey area is located in deep water (>630 m). | Low |
| | Physiological effects on deepwater corals | Unlikely | Negligible | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS. | Low |
| | Physiological effects on cephalopods | Unlikely | Minor | Vessel is underway for the duration of the Toroa 3D MSS.<br>24/7 operations to minimise overall duration of Toroa 3D MSS. | Low |
| Solid and liquid wastes. | Generation of sewage and greywater. | Possible | Negligible | On-board sewage treatment plant.<br>Adherence to MARPOL<br>Approved ISPPC where applicable to vessel class. | Low |
| | Generation of galley waste and | Possible | Negligible | Biodegradable waste discharged overboard beyond 12 Nm from the | Low |

| Aspect or Source | Potential Environmental Effect | Likelihood of Occurrence | Consequence of Occurrence | Proposed Mitigation Measures to Avoid, Remedy or Mitigate Environmental Effects | Risk Category Ranking |
|---|---|---|---|---|---|
| | garbage. | | | nearest land or 3 Nm if comminuted Adherence to MARPOL Annex V. | |
| | Generation of oily waters. | Unlikely | Negligible | Adherence to MARPOL.<br>Oily-water separators.<br>Approved IOPPC where applicable to vessel class.<br>Approved SOPEP. | Low |
| Atmospheric emissions. | Atmospheric emissions. | Unlikely | Negligible | Approved IAPPC where applicable to vessel class.<br>Regular maintenance of motors, equipment and generators. | Low |
| Cumulative Effects | Cumulative sound exposure on marine mammals from two seismic surveys | Unlikely | Negligible | Compliance with the Code of Conduct and mitigation zones.<br>Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day.<br>Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of Toroa 3D MSS.<br>No other known MSS will be underway at the same time as the Toroa 3D MSS. | Low |
| Unplanned activities | | | | | |
| Streamer break or loss. | Water or seabed impact. | Unlikely | Negligible | Solid streamers with SRD fitted.<br>Support vessel present at all times. | Low |
| Fuel or oil spills. | Water and coastal impact. | Unlikely | Negligible | Compliance with COLREGS.<br>Approved SOPEP.<br>Approved IOPPC where applicable to vessel class.<br>Bunkering only occurs during daylight hours and suitable sea conditions.<br>Bunkering operations manned with constant visual monitoring of gauges, hoses, fittings and se surface.<br>Radio communication between seismic and support vessel.<br>All equipment (transfer hose and dry break couplings) are visually checked for integrity.<br>JHA (or equivalent) in place and reviewed before each fuel transfer. | Low |
| Vessel collision or sinking. | Water and coastal impact. | Unlikely | Minor | 24/7 operations to minimise duration of survey.<br>Compliance with COLREGS.<br>Support vessel present at all times.<br>Notice to Mariners issued and coastal navigation warning broadcast on Maritime Radio.<br>All users have been advised of the Toroa 3D MSS operation. | Low |

# 6 Environmental Management Plan

The management of environmental risks associated with WEL's activities is integral to their business decision-making processes. Environmental risks and hazards are identified during planning stages and throughout operations, and their associated risks are assessed and managed via a structured management system. These mechanisms ensure that WEL's high environmental standards are maintained, the commitments specified in this MMIA are achieved and that any unforeseen aspects of the proposed Toroa 3D MSS are detected and addressed.

The Environmental Management Plan (EMP) is essential for the successful implementation of the Toroa 3D MSS; highlighting the key environmental objectives, the mitigation measures and monitoring programmes to be followed as well as the regulatory and reporting requirements and commitments outlined in this MMIA.

The mitigation measures for the Toroa 3D MSS will be implemented to eliminate, offset, or reduce any identified environmental effects to ALARP.

The *Polar Duke* also has its own independent documents for the implementation of their environmental management system as part of their Health, Safety and Environmental Quality Planning process for their operations, waste accounting system, waste management plan and emergency response plan, including for small oil and fuel spills.

The EMP for the Toroa 3D MSS is provided in Table 21 and will be undertaken in conjunction with the MMMP (Appendix 4).

**Table 21: Toroa 3D MSS Environmental Management Plan**

| Environmental Objectives | Parameters to be Controlled | Control Frequency | Proposed Actions | Legislation and Protocols to be Applied |
|---|---|---|---|---|
| Minimise interference with fisheries community. | Presence of fishing boats. | Pre-survey.<br>Continuous. | 24/7 operation to minimise Toroa 3D MSS duration.<br>Information provided to fishing authorities, fishing and boating clubs.<br>Support boat investigation and Notice to Mariners issued and coastal navigation warning broadcast. | COLREGS.<br>International best practice. |
| Minimise introduction of invasive marine species. | Hull fouling.<br>Ballast water discharge. | Continuous. | WEL's IMS standards.<br>Adherence to Import Health Standard for ballast water exchange.<br>Adherence to Craft Risk Management Strategy for biofouling.<br>Regular maintenance undertaken. | International best practice.<br>Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993).<br>Craft Risk Management Strategy for Vessel Biofouling. |
| Minimise disruption and physiological effects to marine mammals and marine fauna. | Presence of marine mammals within mitigation zones while acoustic source is active. | Continuous observation 24 hours per day by four qualified observers.<br>Use of PAM 24/7. | Compliance with Code of Conduct and Section 5.3.<br>24/7 operation to minimise the Toroa 3D MSS duration.<br>Presence of two qualified MMO's and two qualified PAM operators (PAM used 24/7).<br>Pre-start observations, soft start and delay start/shut down procedures. | The Code of Conduct.<br>Marine Mammals Protection Act 1978 & Marine Mammals Protection Regulations 1992. |
| Minimise effects on sea water quality. | Liquid wastes. | Continuous. | Discharge to sea in accordance with MARPOL and NZ regulations. | MARPOL 73/78.<br>NZ Maritime Transport Act 1994. |
| | Oil and other waste. | Continuous. | Disposed at an approved shore reception facility in compliance with legal procedures and maintain a waste disposal log.<br>Approved SOPEP and IOPPC where applicable to vessel class. | MARPOL 73/78.<br>NZ Maritime Transport Act 1994. |
| | Bio-degradable wastes. | Continuous. | Can be discharged overboard beyond 12 Nm from the coastline or 3 Nm if comminuted. | MARPOL 73/78.<br>NZ Maritime Transport Act 1994. |
| Solid waste management. | Solid waste. | Continuous. | Dispose at an approved shore reception facility in compliance with local regulatory requirements. Waste disposal log will be kept. | MARPOL 73/78.<br>NZ Maritime Transport Act 1994. |
| | Bio-degradable wastes. | Continuous. | Discharged overboard from seismic and support vessels, will be comminuted so can occur beyond 3 Nm from coastline. | MARPOL 73/78.<br>NZ Maritime Transport Act 1994. |
| Minimise effects on air quality. | Atmospheric emissions. | Continuous. | Proper maintenance of equipment and generators.<br>Approved IAPPC where applicable to vessel class and regular monitoring of fuel consumption. | Best practice. |
| Minimise accidental events. | Streamer break or loss.<br>Collisions.<br>Fuel/oil spills. | Continuous. | 24/7 operations to minimise survey duration.<br>Solid streamers used with SRD's fitted.<br>COLREGS and presence of a support vessel.<br>Approved SOPEP in place. | Best Practice.<br>COLREGS. |

# 7 Conclusion

Within the petroleum industry, a MSS is considered a routine activity and a requirement to discover and further develop oil and gas fields. Well-established standard operating procedures are in place within the petroleum industry to reduce any potential environmental effects that could arise from a MSS to ALARP.

WEL will comply with the Code of Conduct, NZ Maritime Rules, NZ Marine Protection rules, WEL's internal HSE documents and implement international best practice to ensure there is no harm to any marine mammals, marine fauna, the marine environment or any personnel.

As well as adhering to the Code of Conduct, WEL will implement additional mitigation measures as a reflection of best operator practice. The mitigation zones within the Code of Conduct for a Level 1 MSS were validated by STLM, and were within the SEL thresholds stated in the Code of Conduct. As a result of adhering to the Code of Conduct mitigation zones there should be no injury to any marine mammals. WEL will have two independent and suitably qualified MMO's and two independent and suitably qualified PAM operators on board the *Polar Duke*, and with the use of PAM, observations will be carried out 24/7 while the acoustic source is active.

There is a long history of MSS's around the NZ coastline and to date there has been no significant environmental effects on marine mammals or the marine environment which have been recorded by independent MMO's.

The *Polar Duke* is a specialised MSS vessel that has advanced seismic acquisition technology and environmentally sensitive operational equipment onboard in order to reduce any environmental effects on marine mammals or the marine environment to ALARP.

This MMIA identifies and discusses the potential environmental effects from the Toroa 3D MSS and the mitigation measures that will be implemented to ensure that any potential effects are ALARP.

From the information provided in this MMIA, and the environmental risk assessment undertaken, it is considered that the potential for any adverse effects on the marine environment or marine mammals is ***low***. This assessment is based on the Toroa 3D MSS being undertaken in compliance with the Code of Conduct and the mitigation measures discussed within this MMIA.

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# Appendices

This report contains the following appendices.

| Number | Title |
|---|---|
| 1 | Toroa 3D MSS Information Sheet |
| 2 | Consultation Register with Key Stakeholders |
| 3 | Technical Details of the PAM system |
| 4 | Marine Mammal Mitigation Plan for the Toroa 3D MSS |
| 5 | Sound Transmission Loss Modelling |
| 6 | Toroa 3D MSS Environmental Risk Assessment Summary |

# APPENDIX 1

## TOROA 3D MSS Information Sheet

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

**Woodside Energy Limited**
**Toroa 3D Marine Seismic Survey – Great South Basin**
**Information Sheet**

Environmental Offshore Services Limited (EOS) has been engaged by Woodside Energy Limited to prepare a Marine Mammal Impact Assessment (MMIA) for a 3D Marine Seismic Survey (MSS), 170 km southeast of Bluff in the Great South Basin (Figure 1).

**Survey Details**

The 900 km² Toroa 3D MSS will be located within Petroleum Exploration Permit 55794 to assess hydrocarbon prospectivity in the area. Figure 1 shows the Toroa Survey Area which is bound by the Toroa Operational Area to allow for line changes, acoustic source testing and soft-start initiation.

The Toroa 3D MSS is scheduled to commence in early Q1 2015 and will take approximately one month to complete depending on weather constraints and marine mammal encounters.

**Activity Summary**

Seismic surveying is commonly used in the oil and gas industry to improve understanding of subsurface geology. For the Toroa 3D MSS, seismic data will be collected using a purpose-built seismic survey vessel towing dual acoustic source arrays and hydrophone cables, also known as streamers.

The acoustic emissions from the source arrays will be detected by the hydrophone cables and recorded onboard the seismic vessel. The reflected sound is then processed to provide information about the structure and composition of geological formations below the seabed to identify potential hydrocarbon reservoirs (Figure 2).

Woodside intends to contract a specialist seismic vessel to undertake the Toroa 3D MSS. The seismic vessel is expected to tow 12 streamers up to 8 km long and 100 m apart resulting in a 1,100 m spread of gear being towed that will restrict its ability to manoeuvre (Figure 3). The end of each streamer is marked with a tail buoy that can be observed day and night due to a flashing light and radar reflector. The seismic vessel will traverse the survey area in a series of pre-determined lines at a speed of approximately 4-5 knots or 7-9 km/hr.

A support vessel and a chase vessel will accompany the seismic vessel to ensure the survey area is clear of obstructions and inform other users of the presence of the seismic vessel if they cannot be contacted via VHF radio. A Notice to Mariners will be issued and a coastal navigation warning will be broadcast daily on maritime radio advising of the Toroa 3D MSS for the duration of the survey.

## Environmental Management

Woodside has a long history of successfully conducting marine seismic surveys. The Toroa 3D MSS has been subject to rigorous environmental risk assessment and planning. An environmental risk assessment was conducted in preparation for the Toroa 3D MSS. As a result, a number of mitigation measures and management measures will be implemented during the proposed survey, including:

- Measures to protect marine mammals, including using dedicated marine mammal observers and passive acoustic monitoring during survey activities;
- All routine discharges (sewage/grey water) will meet the relevant requirements of the International Convention of the Prevention of Pollution from Ships 73/78 (referred to as MARPOL (73/78);
- Appropriate spill response plans and equipment will be kept and maintained on vessels; and
- All vessels will be managed as appropriate to prevent the introduction of invasive marine species.

## Environmental Approvals

Woodside will operate the Toroa 3D MSS in accordance with the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Operations' (Code of Conduct). Under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, seismic surveys are classified as Permitted Activities where the operator complies with the Code of Conduct. This requires a MMIA to be prepared and that the mitigation measures for a Level 1 seismic survey under the Code of Conduct are adhered to in order to prevent any adverse effects on the marine environment or marine mammals. The Director-General of Department of Conservation is required to give formal sign off to the MMIA before the Toroa 3D MSS can commence.

## Contact Details

If you have any further questions or matters you would like to discuss or you would like any further information in regards to the Toroa 3D MSS, please contact Dan Govier of EOS.

Dan Govier
Environmental Consultant
Environmental Offshore Services Ltd

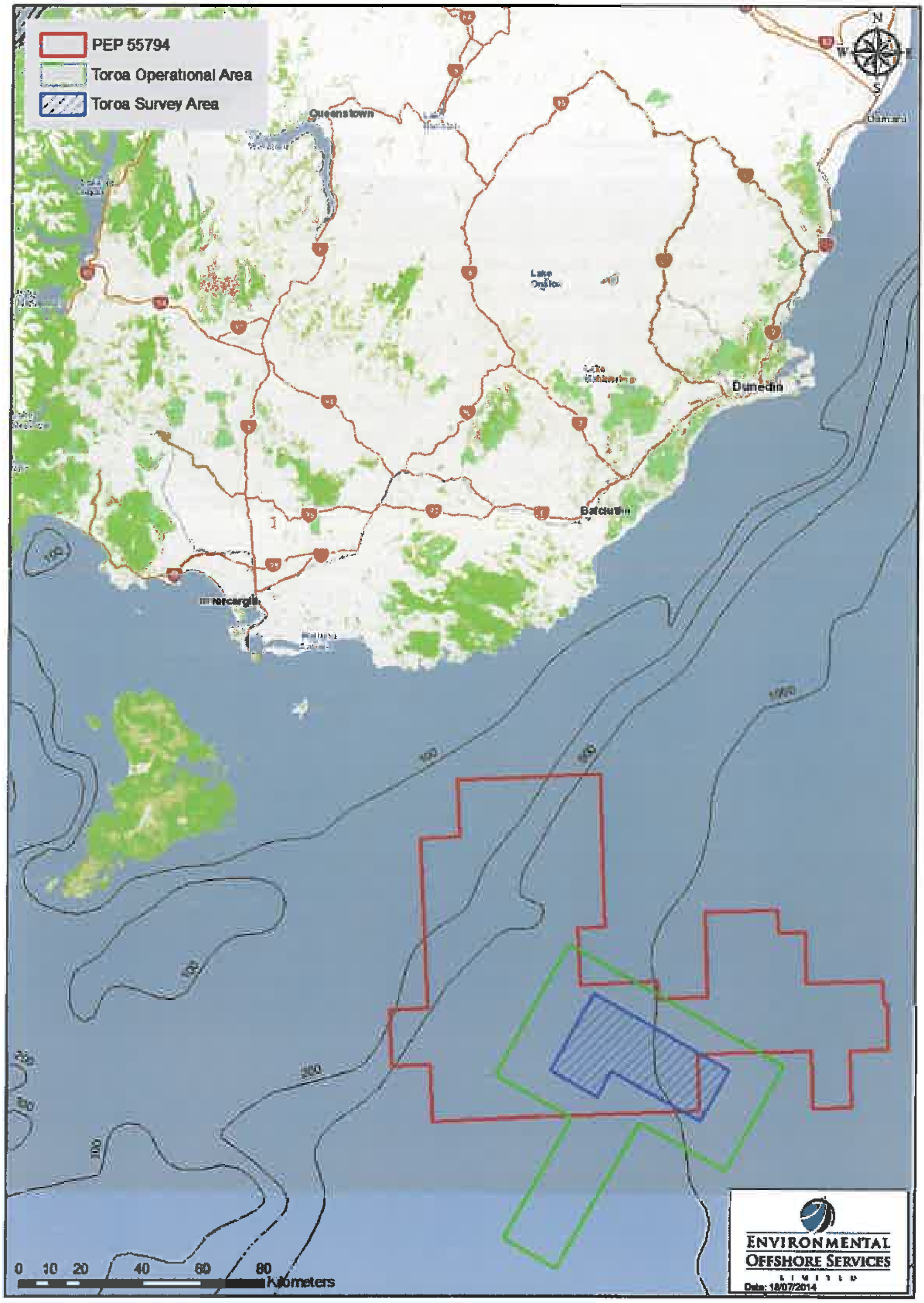


**Figure 1: Toroa 3D Survey Area and Toroa Operational Area**

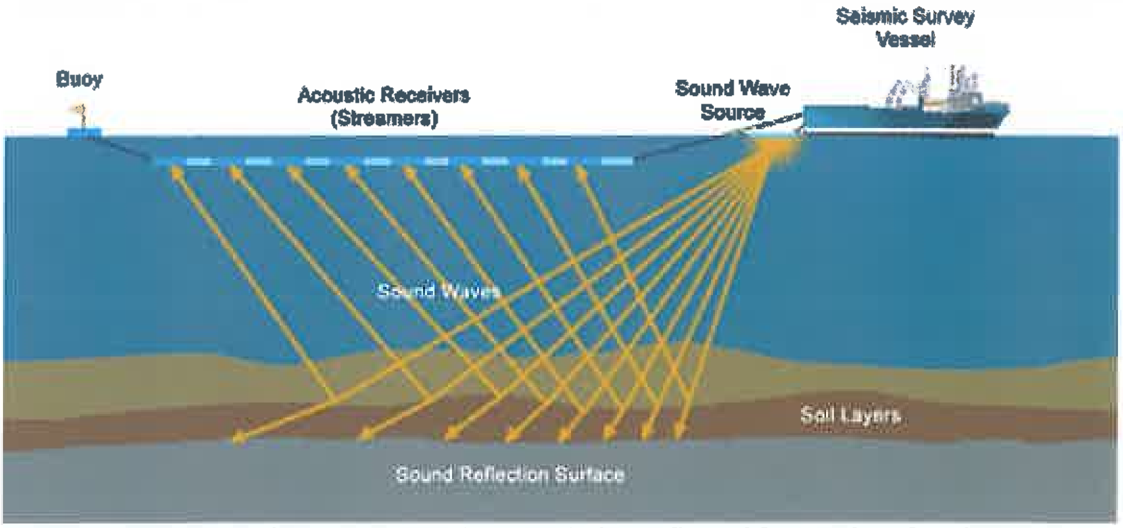


**Figure 2: Schematic of acoustic sound source being reflected from subsurface layers**

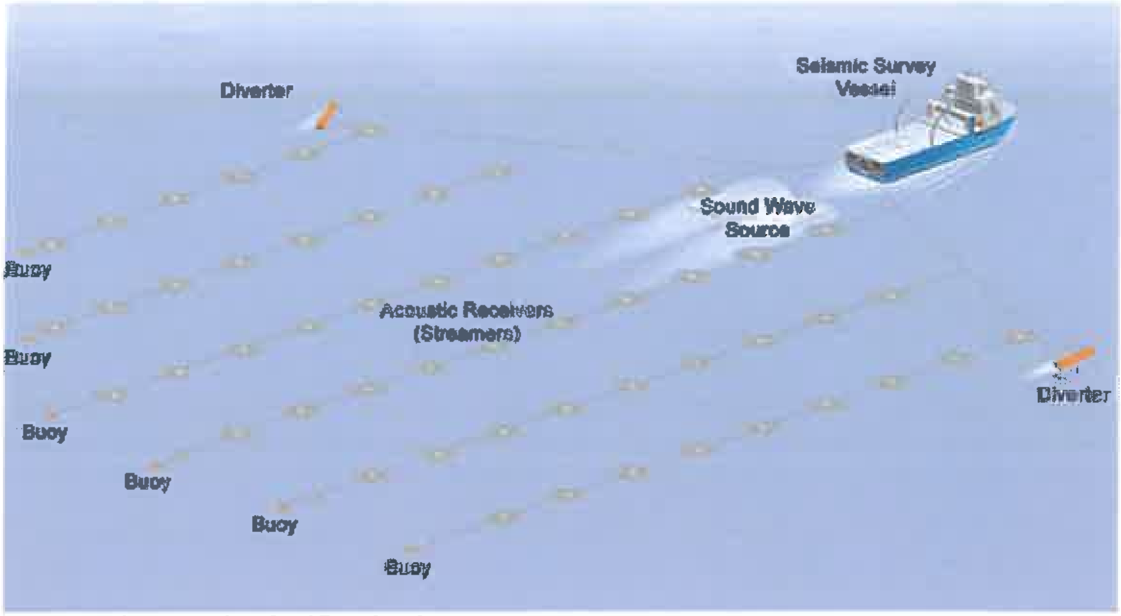


**Figure 3: Schematic of a 3D seismic survey**

# APPENDIX 2

## Consultation Register with Key Stakeholders

| Stakeholder | Consultation Summary |
|---|---|
| EPA / DOC – Wellington<br>24 February 2014 | An introductory meeting with EPA and DOC staff in Wellington, with WEL and NZOG in attendance. WEL provided a company overview and summary of the work program commitments attached to the exploration permit. EPA / DOC provided an overview of the governing regulations under the EEZ act and the requirement to comply with the seismic code of conduct. A discussion over the consultation process, and the need to engage broadly with iwi and community groups that have an interest in the area of operation. |
| Environment Southland<br>1 April 2014 | An introductory meeting with Environment Southland (ES) in Invercargill, with WEL and NZOG in attendance. WEL and NZOG provided company overviews and summary of the work program commitments attached to the exploration permit. ES provided an overview of oil and gas exploration activities in the region and an opinion on community sentiment.<br>ES suggested including the Invercargill City Council and the Southland Energy Consortium in the consultation process. WEL undertook to keep ES informed of work progress and plans in lead up to seismic program. |
| Ourway Southland<br>1 April 2014 | An introductory meeting with Ourway Southland (OS) in Invercargill, with WEL and NZOG in attendance. WEL and NZOG provided company overviews and summary of the work program commitments attached to the exploration permit. OS provided an overview of the business climate and community challenges for the region. OS suggested including Invercargill City Council in future consultation. |
| Venture Southland<br>1 April 2014 | An introductory meeting with Venture Southland (VS) in Invercargill, with WEL and NZOG in attendance. WEL and NZOG provided company overviews and summary of the work program commitments attached to the exploration permit. VS provided WEL and NZOG with an overview of the regional capability to support future activities. |
| Oraka-Aparima Runaka, Waihopai Runaka, Awarua Runanga, Hokonui Runanga<br>1 April 2014 | An introductory meeting with Murihiku Runanga, hosted by Te Ao Marama, with WEL and NZOG in attendance. WEL and NZOG provided company overviews and summary of the work program commitments attached to the exploration permit.<br>A general discussion follow, listening to the concerns and opportunities for iwi participation in the oil and industry. Key points highlighted were the importance of Titi, and the potential for training iwi MMO. The cultural and traditional importance of kaimoana and the guardianship of the sea were emphasised. |
| Te Rūnanga o Ngāi Tahu<br>26 May 2014 | An introductory meeting between Te Rūnanga o Ngāi Tahu (Ngai Tahu) and WEL in Christchurch. WEL provided a company overview and summary of the work program commitments attached to the exploration permit. Ngai Tahu provided WEL with an overview of the cultural landscape and Ngai Tahu structure. Ngai Tahu also advised they had input into the seismic code of conduct so were familiar with the obligations under the code. Key areas of interest included possibilities for iwi participation, in particular MMO / PAM training. The sentiment of Iwi groups towards oil and gas exploration was also discussed, with some groups wanting to understand how communities will benefit from oil and gas exploration, with all of the perceived risks associated with these activities. It was also recommended WEL contact fisheries groups which may be impacted by the survey which has been done through the Deepwater Group. WEL undertook to keep Ngai Tahu informed about the MMIA process and provided information to Ngai Tahu about the |

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| | effects of a seismic source in a recent scallop mortality study. |
| Deepwater Group | A meeting was held with the Deepwater Group (DWG) to introduce the proposed survey area and to listen to any concerns that may result from the fishers relating to the proposed survey. A fisheries assessment was underway but the results were not yet available. DWG requested that as soon as the fisheries assessment was available if they could receive a copy and they would distribute it to all the relevant parties that fish in that area. The DWG subsequently distributed the fisheries assessment to the fishing industry and no questions were asked over the survey. This was also supported by the Information Sheet providing more details of the survey. |
| DOC – Dunedin<br>29 July 2014 | An introductory meeting between WEL and DOC Dunedin. WEL provided background on WEL and the proposed survey in the GSB. DOC Dunedin confirmed that they are going to represent DOC – Southland office for this project at their request. A summary was provided on the MMIA, STLM, fisheries assessment, and details of the seismic operations (i.e. survey, support and chase vessels). DOC provided a summary of what marine mammals are likely to be in the area during the summer period (dusky dolphin, orca, maybe sea lions, NZ fur seals). General discussion over marine mammal strandings in the area and the implementation of necropsies on any stranded marine mammals as part of the mitigation measures. A brief discussion was also held on bird species in the area, in particular titi, which WEL have been in discussion with Te Au Marama regarding titi. WEL are to keep DOC informed on the progress and timings of survey as things progress. |
| Otago University<br><br>29 July 2014 | WEL provided an overview of WEL and the proposed activities in the GSB. questioned the baseline sources associated with the MMIA from previous sighting data, as the sightings are not representative of actual species present due to the fact that they are associated with sightings during seismic surveys. The main concern from the seismic activity is the potential effect on beaked whales. The details of the MMOs were discussed and the team that WEL had selected, it was also noted that if any crew observe a mammal there is provisions to record this, and likewise from the support vessel. STLM was discussed and was very interested in the modelling results and field validation as part of university projects. Otago university may look to measure sound levels during the survey. WEL provided summary of their involvement in the Behavioural Response of Australian Humpback Whales to Seismic Surveys (BHRASS). WEL help co-fund this work and also gave an overview of WEL's environmental approach to partner with leading experts with focus on transparency with intent of publishing research material as a result. |
| Invercargill City Council<br>30 July 2014 | WEL provided an overview of WEL, seismic acquisition and WEL's proposed activities in the GSB. The council acknowledged that WEL is not required to engage with the Council due to being outside the CMA, but appreciated WELs desire to engage more broadly. The Council requested that WEL send them a letter with key information, prior to the vessel moving to the GSB so that they are briefed of the activities within their region. |
| Southland Energy Consortium – Venture Southland<br>30 July 2014 | A follow up meeting was held from the initial meeting earlier in the year (April 2014). Further information on the proposed activities and the timing of the survey was discussed. Southland Energy consortium provided overview of what their role is within Southland, they are actively involved in up-skilling the local workforce. Discussions were |

| | |
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| | held over the suitability of South Port to support seismic operations. |
| Environment Southland<br>30 July 2014 | Follow up meeting between WEL and Environment Southland as stated in April 2014. WEL provided overview of the propose survey and survey areas in the GSB. Discussion was held over how Southland could respond to the needs of the oil and gas industry, where it was pointed out the South Port would be very accommodating. WEL are to continue to keep Environment Southland informed. |
| Te Ao Marama Inc<br>31 July 2014 | A follow up meeting from the meeting held between WEL and the four Southland Runanga in May 2014. This meeting was intended to be a combine hui that included Oraka-Aparima Runaka, Waihopai Runaka, Awarua Runanga and Hokanui Runanga, but not all could make it due to other commitments. It was suggested by Te Ao Marama that they may be suffering from 'consultation fatigue' due to the large number of engagements with the oil and gas industry lately; however no solution was determined regarding the consultation fatigue. The proposed seismic survey and regulatory process was discussed with a number of questions asked, and answered during the discussion.<br><br>A good discussion was held on the significance of Titi in the Southland region, where considerable effort is made to protect the bird. Following an oil spill in California, some of the dead birds were linked back to NZ and received funding which assisted in the Titi tagging study which provided further information on their migration patterns. The history of the birding and Titi season was also provided. |
| Te Rūnanga o Ngāi Tahu<br>1 August 2014 | A follow up survey between WEL and Ngai Tahu which was held in May 2014. WEL provided an overview of the proposed survey and regulatory process. A discussion was held over the MMO training course that is being proposed and the ability of course attendees to gain enough relevant sea time. The pest eradication programmes being run down on Stewart Island was discussed and the benefits of this to the entire community. |
| Te Awarua Runanga<br>17 September 2014 | A hui was held on the Te Rau Aroha Marae in Bluff, with WEL and NZOG in attendance. WEL provided an overview of the company and the proposed survey as well as a summary of seismic surveys, the differences between sound in water and air and the regulatory process. The Titi was raised and its importance as being a taonga species for iwi. A discussion was had over the potential interaction with the survey. The cultural and traditional importance of kaimoana and the guardianship of the sea was again emphasised; this has a very high consideration with all iwi. |

## Dan Govier

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**To:** Gdq#Jrylhu
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Kia ora Dan,

Thanks for your calls. I can confirm our meeting at 12 pm on Tuesday the 29th of July here at our Otepoti/ Dunedin Office in Lower Stuart Street. Please come into reception on the 1st floor when you arrive.

I have let staff based at our Murihiku office know that you would be available to meet with them the following morning, but I am unable to confirm anyone would be available for a meeting then. Service staff from the Murihiku office are happy for us to cover marine mammal and biodiversity issues during our discussions here in Dunedin.

We look forward to meeting with you next Tuesday.

**Conservation for prosperity *Tiakina te taiao, kia puawai***

www.doc.govt.nz

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**From:** Dan Govier |
**Sent:** Monday, 14 July 2014 2:59 p.m.
**To:** Jim Fyfe
**Subject:** Woodside Energy Seismic Survey

Hi .
Hope you are well.

I am working with a company called Woodside Energy who are proposing to undertake a 900 km$^2$ 3D seismic survey in the Great South Basin early next year.

We are going to be undertaking some consultation on the week of July 28th and was wondering whether you would be available to meet with us that week to discuss the project and raise any concerns or potential sensitivities in the area.

I have attached a map of the Permit area, and the survey, although still being confirmed is in the southern offshore part of the permit area.

Once we have a few more details regarding when we are in Dunedin we can confirm the timing, but likely to be earlier in the week if that suits?

Look forward to hearing from you soon.

Cheers
Dan

**Dan Govier**
Environmental Consultant

ENVIRONMENTAL
OFFSHORE SERVICES
LIMITED

## Dan Govier

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Kia ora tatou,

On Tuesday 29th July we had an informative meeting with representatives for Woodside Energy Ltd ( the NZ Manager and Mat Hatch, Environmental Advisor) and Dan Govier who is working for EOS Ltd to assist Woodside Energy Ltd to undertake their environmental assessment for the proposed Toroa 3D seismic survey planned for this coming summer.

I have attached a brief sent through from Dan outlining the consultation process.

The survey is planned for February/ March next year and is expected to 35 days (including down time). As well as the seismic ship (which is yet to be confirmed) there will be a support vessel and a chaser. They will be working in accordance with the code of conduct so we can expect weekly reports regarding marine mammal sightings, shutdowns resulting from encounters etc. Woodside will undertake acoustic monitoring inshore of the survey area which, together with the modelling they will conduct once they have identified the survey vessel, will provide some understanding of the underwater noise that will be propagating inshore. Importantly this monitoring station will be placed between the survey area and the Porpoise Bay Marine Mammal Sanctuary.

They agreed to our request for assistance with undertaking necropsies for any stranding or beaching events over the period of operation and for two weeks after. This will cover Stewart Island and from the western end of Te Waewae Bay to Moeraki Peninsula on the mainland and they also agreed that if anything unusual turned up during the survey period that was outside this identified area they would still consider assisting on a case by case basis.

Dan invites us to contact him if anyone has further questions or relevant information they can provide regarding the use of this area by marine mammals or other wildlife.

**Conservation for prosperity** ***Tiakina te taiao, kia puawai***

www.doc.govt.nz

## Dan Govier

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**Sent:** Wkxuvgd|/#4;#Vhswhp ehu#5347#43=3<#dp 1
**To:** jdlC dz duxd1ruj1q}
**Cc:** Gdq#Jryhu
**Subject:** Wkdqnv#iru#|rxu#wlp h#|hvwhugd|

Kai ora (

Thanks for your help in including us in yesterday's hui. It was really good to meet some of the people who have such a good, and long understanding of the area and listen to their concerns. I hope we gave you some good information about our plans and what is involved in the survey. Dan is pretty good at explaining this stuff, much better than I am!

As a follow up we looked into the sighting records of the Shell seismic survey from DOC, particularly for information about titi. There were no specific sightings of titi recorded.

To make sure everyone is kept up to date, should I pass any information or updates to yourself?

Thanks again for your help, don't hesitate to contact me if you have any questions or concerns.

Best regards,


Country Manager New Zealand
Exploration Australasia

Woodside Energy (New Zealand)
Level 16
Vodafone on the Quay
157 Lambton Quay
Wellington 6011
New Zealand

T: +
T: +
M: ·
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## Dan Govier

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| **From:** | Gdq#Jrylhu |
| **Sent:** | Vxqgd\|/#45#Rfwrehu#5347#43=58#sp 1 |
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Hi all,
In additional to the email that            sent below back in August, I have attached an information sheet for the proposed seismic surveys that Woodside Energy will undertake early next year.

The seismic survey vessel *Polar Duke* has been contracted and will be accompanied by the support vessel *Sanco Sky*. It is likely that an additional chase vessel will be working with them as well although that has not yet been confirmed.

Both surveys are proposed to take approximately 35 days to complete.

The Taranaki survey will begin first at the start of January 2015, then following completion of this, the vessel will travel to the Great South Basin, with a port call along the way somewhere, so it is likely to be February/March by the time the vessel is in the Great South Basin.

If you have any questions or concerns relating to the attached information sheet or the proposed seismic survey please let me know.

Kind Regards,
Dan

**Dan Govier**
Environmental Consultant
ENVIRONMENTAL
OFFSHORE SERVICES
LIMITED

**Sent:** Friday, 1 August 2014 8:43 a.m.

**Subject:** RE: Dan Govier meeting re seismic surveys, planned and possible - update with maps provided by Woodside.

Dear All,

Following the email sent 25 July, I now attach the maps of the two areas discussed below.

There appears to be very little overlap in regard survey proposal 2 but some with proposal 1.

I suggest that if proposal 1 turns from proposal to plan, maximum warning of dates to be undertaken will be required to prevent any conflict with fishing operations.

If any wish further discussion on this matter please advise so I can confer with Dan Govier about how and when to do this.

**Regards,**

*Fisheries Specialist*

deepwater group

Deepwater Group Ltd

**W** www.deepwatergroup.org



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**From**
**Sent:** Friday, 25 July 2014 10:16 a.m.
**To:**

**Subject:** Dan Govier meeting re seismic surveys, planned and possible

Dear All,

1) There is a concept plan for a survey west of Taranaki in January 2015 in 500-1000 metres. This is still a plan in development. Dan has agreed to ask client if we can see the fisheries overlap data as soon as produced by MPI. Until this is complete we can only be on standby for this proposal. I will circulate information on arrival.
2) There is a concept plan for a survey in an area in deepwater ESE of Stewart Island (Feb-March 2015, ie after Taranaki above and by same vessel). There is likely to be little if any overlap but again as per 2) above, MPI will have information soon so we can determine who and to what extent we need to manage any conflict.

I reminded Dan that wrt seismic surveys we held four broad concerns:

1) Navigational conflict to fishing ops
2) Fish scaring increasing cost of catch
3) Fish scaring when research being undertaken
4) Impact on species eg potential for damage to spp such as scampi as previously advised

Communication well in advance best mitigation.

Any questions please advise.

**Regards,**

*Fisheries Specialist*

Deepwater Group Ltd

**W** www.deepwatergroup.org

*This email is intended solely for the use of the addressee and may contain information that is confidential or subject to legal professional privilege. If you are an unintended recipient of this email please immediately notify the sender and delete the email.*

# APPENDIX 3

## Technical Details of the PAM System

**Seiche Measurements Ltd**
Bradworthy Industrial Estate
Langdon Road, Bradworthy
Holsworthy, Devon EX22 7SF
United Kingdom

F
Email: info@seiche.eu.com
Web: www.seiche.eu.com

**Seiche Measurements LLC**
10801 Hammerly Boulevard
Suite 114, Houston
Texas TX77043
USA

Fa
Email: bpadovani@seiche.eu.com
Web: www.seiche.eu.com

**11 November 2014**

# 250m Array System and 230m tow with 20m detachable array System Specifications

**Commercial in Confidence**

## Contents

# 1)Towed PAM

The system is designed to give a flexible approach to the monitoring of marine noise from a towed hydrophone system. The system comprises an array cable, tow cable, deck cable, an electronics processing unit and laptops supporting Pamguard software.

The electronic processing unit contains a buffer processing unit comprising of power supplies, buffer boards, national instrument card for high frequency signal and usb1208 for depth. There is also a radio transmission system that is used to process hydrophone signals for audio output to remote headphones.

*Figure 1:* 8U Base unit with Rack-mounted PC and LF and HF monitors

## Remote Monitoring Station

*Figure 2: Remote station on bridge and set up screen for Rack mounted base unit*

The remote monitoring station enables the base unit to be rack-mounted with other ship based computer equipment and by using the ships internal ethernet system, link to screens in an alternative location on the vessel.

# Electronics Monitoring Base Unit

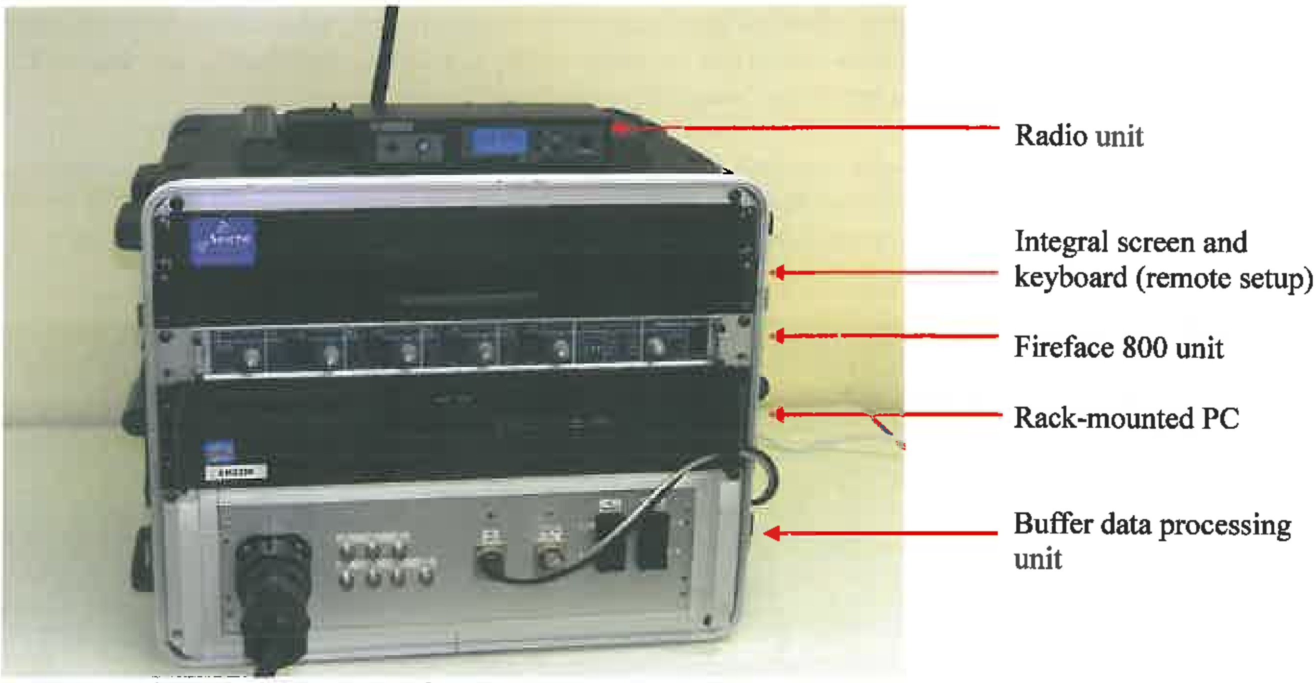



*Figure 3: Electronics monitoring base unit*

**Radio unit**
The radio system provides a remote headphone output from the audio output system. (Note: it is limited in frequency to 16 kHz)

**Integral screen and keyboard**
The rack-mounted integral screen and keyboard can be used to run the rack-mounted PC for monitoring or for troubleshooting. It is contained in a 1U housing which slides out and flips up when in use.

**Fireface 800 unit**
This unit is used for the low frequency signal. The analog signal from each hydrophone is sent from the back of the buffer data processing unit to the fireface unit. The detected signals are filtered and amplified then fed to the rack-mounted PC via the firewire cable.

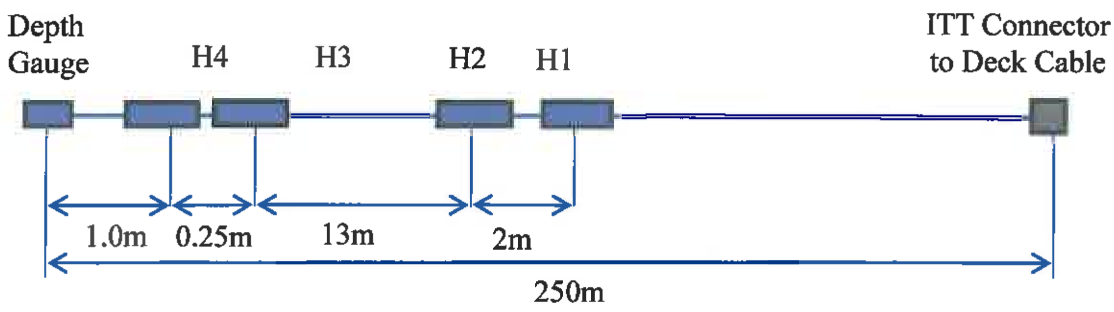
**Rack-mounted PC**
The rack-mounted PC system has an Intel quad core i5 processor with 8 GB of RAM. This custom built PC system has enough power to run both high and low frequency audio data through Pamguard simultaneously from up to 4 hydrophones.

**Buffer data processing unit**
This unit connects the deck cable into the system and splits the analog signal from up to 4 hydrophones into high and low frequency acoustic data. The high frequency analog signal is converted into a digital signal and is fed via USB to the rack-mounted PC for real time analysis and display. The low frequency analog signal from 4 hydrophones is fed into the fireface unit which is connected to the PC via firewire. The high and low frequency signal can also be listened to using the BNC connectors for troubleshooting. There is a second USB that enables the depth sensor readings to be input to the PC.

# Towed Sensors

**Note that frequency bandwidths can be tailored to suit specific applications and country requirements.**

**250m Towed Array**
The sensor array comprises a 250m array with integral hydrophones and a depth sensor array.




**Mechanical Information**

| | |
|---|---|
| Length: | 250m |
| Depth Rating: | 100m (not connector) |
| Diameter: | 14mm over cable, 32mm over mouldings, 64mm over connectors |
| Weight: | 60kg |
| Connector: | ITT 19 pin |
| BS | 500 kg |

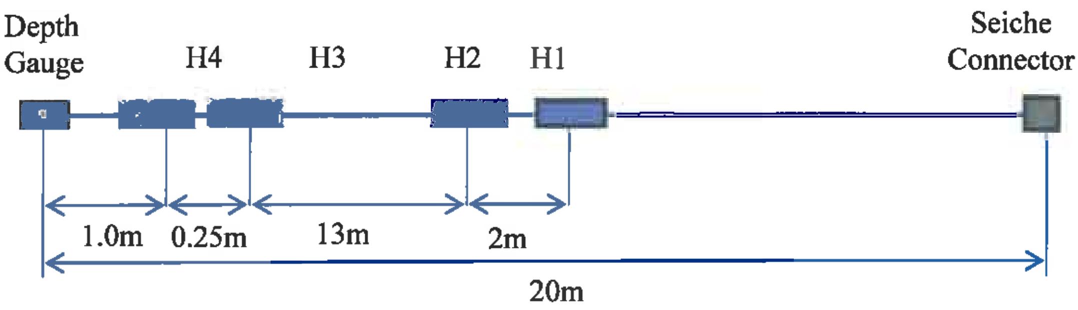
**Hydrophone elements**

| | | |
|---|---|---|
| H1 | Broadband | 10 Hz to 200 kHz (3dB points) |
| H2 | Broadband | 10 Hz to 200 kHz (3dB points) |
| H3 | Wideband | 2 kHz to 200 kHz (3dB points) |
| H4 | Wideband | 2 kHz to 200 kHz (3dB points) |

| | | |
|---|---|---|
| Spacing H1 - H2 (HF detection) | 2.00m | 1.28mSecs |
| Spacing H2 - H3 (HF detection) | 13.00m | 8.32mSecs |
| Spacing H3 - H4 (LF detection) | 0.25m | 0.16mSecs |

**20m Towed array**

The sensor array comprises a 20m detachable array section with a 230m heavy tow cable. The connectors are designed in house and are fully waterproof. Longer array sections can be provided to improve detections of low frequency vocalising marine mammals.




**Mechanical Information**

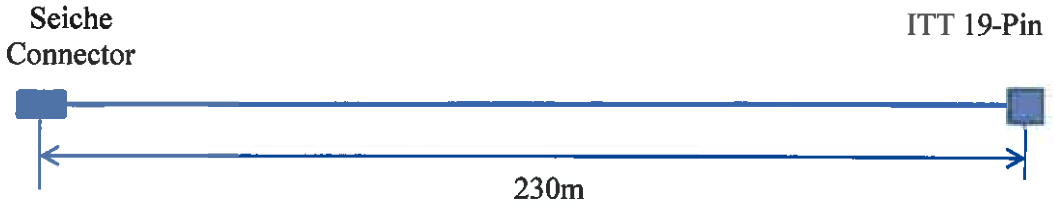
| | |
|---|---|
| Length: | 20m |
| Depth Rating: | 100m (not connector) |
| Diameter: | 14mm over cable, 32mm over mouldings, 45mm over connectors |
| Weight: | 60kg |
| Connector: | Seiche |
| BS | 500 kg |

**Hydrophone elements**

| | | |
|---|---|---|
| H1 | Broadband | 10 Hz to 200 kHz (3dB points) |
| H2 | Broadband | 10 Hz to 200 kHz (3dB points) |
| H3 | Wideband | 2 kHz to 200 kHz (3dB points) |
| H4 | Wideband | 2 kHz to 200 kHz (3dB points) |

| | | |
|---|---|---|
| Spacing H1- H2 (HF detection) | 2m | 1.28mSecs |
| Spacing H2 - H3 (HF detection) | 13m | 8.32mSecs |
| Spacing H3 - H4 (LF detection) | 0.25m | 0.16mSecs |

**230m Tow cable**

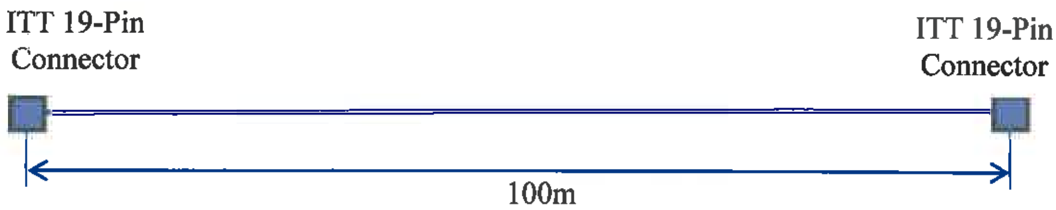



**Mechanical Information**

| | |
|---|---|
| Length | 230m |
| Diameter | 17mm over cable |
| Connector | Seiche 36-pin 45mm over connectors |
| | ITT 19-pin 65mm over connectors |
| Weight | 95 kg |
| BS | 960 kg |

**100m Deck Cable**

The deck cable is used for all array options




**Mechanical Information**

| | |
|---|---|
| Cable Length: | 100m |
| Diameter: | 14mm |
| Connectors: | 19 pin ITT (one male, one female) |
| Connector Diameter: | 64mm |
| Weight: | 25 kg |
| BS | 500 kg |

## 2) System Sensitivity

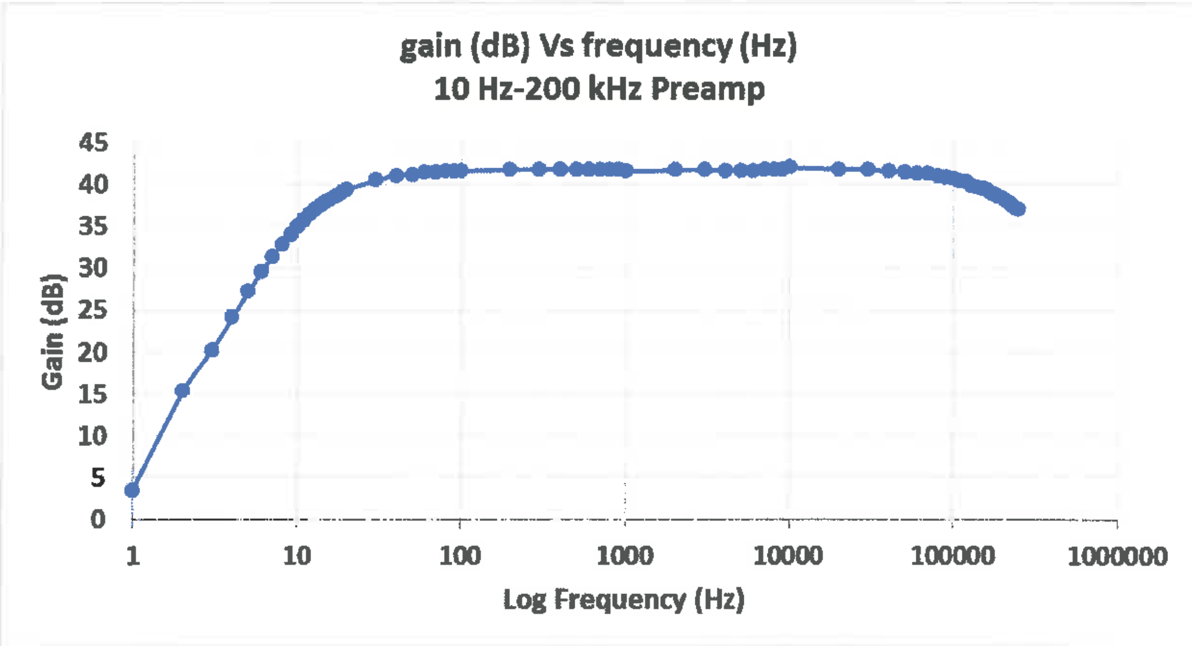



*Figure 4: Hydrophone Sensitivity*

The array sections consist of four hydrophones.
Two are set with a bandwidth of 10 Hz to 200 kHz, per Figure 4 above, which demonstrates that the sensitivity of the hydrophone starts to roll off at 10 Hz, but remains sensitive down to 1 Hz where it will still register 4 dB

The second pair of hydrophones is set to a bandwidth of 2 kHz to 200 kHz sensitivity. This will ensure that if the lower frequency pair of hydrophones is saturated by vessel noise, the system will still be capable of detecting vocalising marine mammals.

# APPENDIX 4

## Marine Mammal Mitigation Plan for the Toroa 3D MSS

# Marine Mammal Mitigation Plan:

## Woodside Energy (New Zealand) Limited – Toroa 3D Marine Seismic Survey

BPM-Woodside-Toroa 3D MSS-MMMP-v1.2

18/12/2014

BLUE PLANET MARINE

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**Date: 18/12/2014**

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| Woodside | Senior Geophysicist | 1 |
| Woodside | Country Manager New Zealand | 2 |
| Woodside | Environment Advisor Exploration | 3 |
| EOS/SLR | Environmental Consultant | 4 |
| BPM | Senior Marine Scientist | 5 |
| BPM | Managing Director | 6 |

## Document Revision Record

| Rev. | Date | Description | Prepared | Reviewed | Approved |
|---|---|---|---|---|---|
| 1.0 | 12/12/2014 | Version 1 | LD | SC, DG | |
| 1.1 | 18/12/2014 | Comments incorporated | LD | SC | |
| 1.2 | 18/12/2014 | DOC comments incorporated | LD | SC | SC |
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Document Reference Number: BPM-Woodside-Toroa 3D MSS-MMMP-v1.2

Prepared by:

Last updated: 18 December 2014



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# 1. Introduction

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

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

# 2. The Woodside Energy (New Zealand) Limited – Toroa 3D Marine Seismic Survey

Information provided in the MMIA for the survey has been used by BPM in the development of this MMMP. EOS was engaged by Woodside to prepare a MMIA for an approximate 1,140 km$^2$ survey in the Great South Basin, scheduled to commence in late February 2015. The survey area will be located largely within PEP 55794 and will be bound by an Operational Area allowing for line turns, acoustic source testing and soft start initiation (Figure 1). A well tie will take place from the Survey Area consisting of one swath of seismic acquisition to the previously drilled Pakaha-1 well to tie in the down hole stratigraphy data from the Pakaha-1 well to the survey.

The primary objective of the survey is to assess hydrocarbon prospectivity within the area, and if successful, identify possible locations for an exploration well to target any potential reservoirs. It is anticipated that the survey will take approximately 35 days to complete, depending on weather constraints and marine mammal encounters. Operations will be conducted 24 hours per day, 7 days per week; also subject to suitable weather conditions and marine mammal encounters.

## 2.1 Seismic vessel and acoustic source

The survey will use the seismic vessel *Polar Duke* and will tow 12 solid streamers, 7 km in length and 100 m apart. The acoustic source will have an effective volume of 3,460 in$^3$ and will be comprised of three sub-arrays with seven acoustic sources on all but one of the sub-arrays, which has nine. The acoustic array will be located at a depth of 7 m below the sea surface and approximately 130 m behind the survey vessel. The depth of the sub-arrays will ensure that the volume used enables the survey to be run effectively in regards to data acquisition, but also to minimise the potential environmental disturbance. In the case of dropouts during acquisition, the gun array may operate at a slightly lower capacity for a short period of time.

The acoustic source will have an operating pressure of 2,000 psi and will be fired at a sourcepoint interval of 18.75 m apart. For a typical boat speed of 4.5 knots (kts), this equates to a sourcepoint activation every 8 seconds. Given the volume of the acoustic source being used, the survey is classified as a **Level 1** survey under the Code. The mitigation procedures set out in this MMMP will adhere to the requirements of a Level 1 survey as stipulated in the Code and any additional mitigation measures determined via the MMIA process and outlined in Section 5 of this document.

The *Sanco Sky* will act as support vessel and be in close proximity to the *Polar Duke* for the duration of the survey, except when required to go into port for supplies. A chase vessel will also be utilised for the duration of the survey.

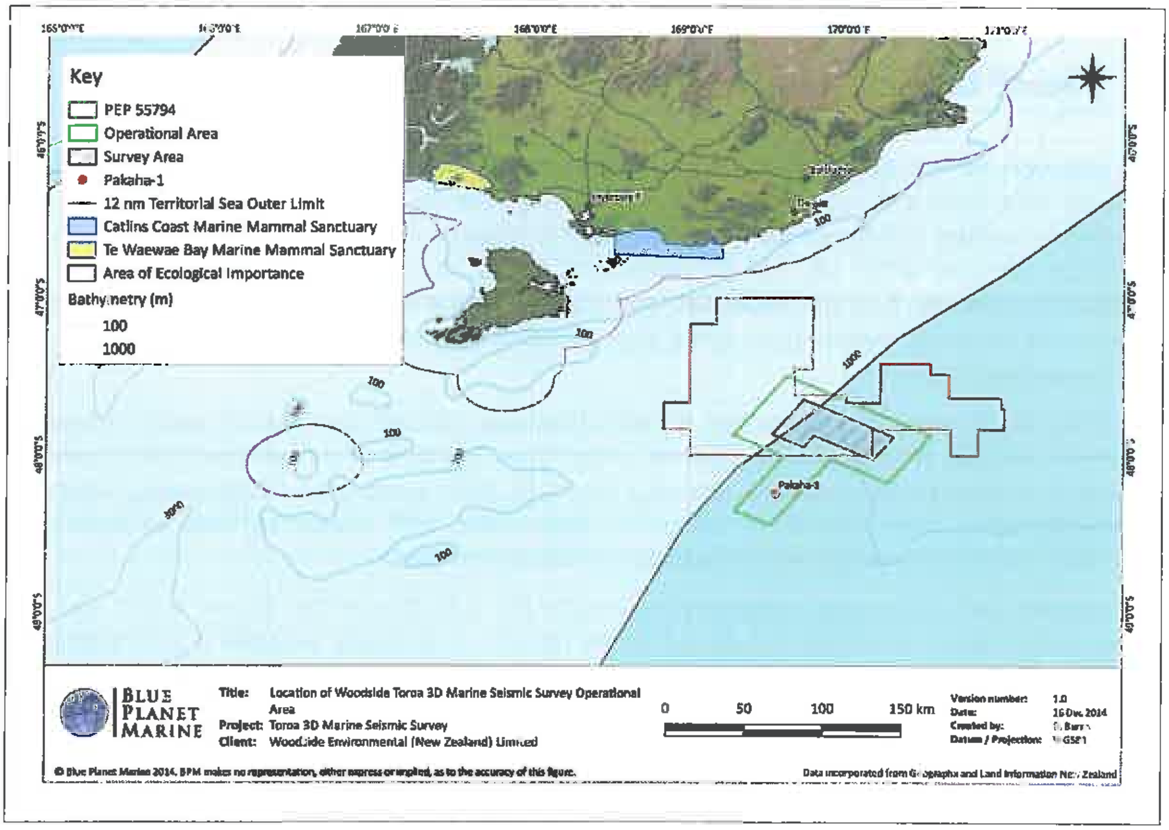



Figure 1: Location of the Woodside Toroa 3D Marine Seismic Survey.

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

## 2.2 Operational Area

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

When a MSS is proposed within Areas of Ecological Importance (AEI), the Code requires Sound Transmission Loss Modelling (STLM) to be undertaken in order to validate the standard mitigation zones specified in the Code. Part of the Operational Area for this survey is located within AEI and so STLM is required.

Woodside's STLM was based upon the specific configuration of the acoustic array deployed from the *Polar Duke* and the environmental conditions within the Operational Area. The STLM predicted that the standard mitigation zones described in the Code will be adequate for the protection of marine mammals and that Sound Exposure Levels (SEL) will be equal to or below the behaviour and injury criteria thresholds specified for mitigation in the Code. There is no need, therefore, to either extend the radius of the mitigation zones or limit acoustic source power.

There are two Marine Mammal Sanctuaries (MMS) in the vicinity of the survey. The Catlins Coast MMS and Te Waewae Bay MMS are respectively located approximately 110 km and 215 km to the northwest of the Operational Area. Both MMS include areas where Hector's dolphins are found. Due to its distance offshore, it is unlikely that Hector's dolphins will be sighted within the Operational Area.

## 3. Record Keeping and Reporting

The observers (MMOs and PAMOs) are responsible for maintaining records of all marine mammal sightings/detections and mitigation measures taken throughout the survey. Observers are also required to monitor and record seismic operations, the power output of the acoustic source while in operation, observer effort and sighting conditions. These and other reporting requirements are detailed in Appendix 2 of the Code. Sections 4.2.4.3; 4.2.4.4 and 4.2.5 of the MMIA present a summary of the most commonly occurring or protected marine mammal species known to occur in the Operational Area.

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

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

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

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

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

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

It is recommended that observers test the functionality of the datasheets prior to mobilisation and become familiar with their use. In particular, note that macros <u>must</u> be enabled.

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

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

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

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

In addition to the recording and reporting requirements of the Code, Woodside has committed to the following:

- A MMO will be on watch and recording marine mammal sightings during transit from the Vulcan Operational Area to the Toroa Operational Area during daylight hours and in good sighting conditions.
- At the start of seismic operations, a vessel self-noise assessment will also be undertaken by the PAMOs and will be provided to DOC.

## 3.1 Hector's dolphin sightings

The survey is being acquired in waters 110 km and 215 km beyond the Catlins Coast MMS and Te Waewae Bay MMS respectively. Due to its distance offshore, it is highly unlikely that Hector's dolphins will be sighted within the Operational Area. They may be sighted in more coastal waters, however, during transit. If a Hector's dolphin sighting is made during the survey, DOC should be notified as soon as possible. Refer to Section 6 for notification details.

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

As outlined in Section 2, Woodside have undertaken STLM and will ground-truth its results during the survey. Representative data recorded on the seismic streamers during the seismic survey will be used to compare actual water column sound exposure levels with pre-survey modelled predictions. These results will be verified to ensure the mitigation zones are appropriate. The validation results and report will be provided to DOC by Woodside.

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

Note: STLM for the survey confirmed that the mitigation zones defined in the Code are predicted to sufficiently protect marine mammals from physiological and behavioural changes. Thus, Woodside is not required to implement additional mitigation measures. Woodside has, however, committed to implement additional mitigation actions unrelated to STLM. These mitigations are outlined in relevant sections of this MMMP and are summarised in Section 5.

Refer to Section 5.1.2.1 and Appendix 5 of the MMIA for details of the STLM.

## 3.3 Contact details for the Department of Conservation

During the survey, the first point of contact within DOC is or ). If a response is required urgently then telephone communications are recommended but in all other circumstances email correspondence should suffice. Should Ian Angus be unavailable, please phone 0800DOCHOT (0800-362-468) and state the following:

1) You wish to provide information to the Marine Species and Threats Team, National Office;
2) The name of the MMO/PAMO, the seismic survey and boat you are currently on;
3) The time and date;

4) The issue/enquiry they wish to pass on to I and

5) Where you can be contacted with a reply (if appropriate).

### 3.3.1 Communication protocol

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

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

- MMO Team Leader to contact BPM Project Manager ashore ;
- BPM to contact Woodside ; and
- Woodside to contact DOC .

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

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

# 4. Mitigation Measures Required Under the Code

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

1) The use of dedicated observers (i.e. MMOs and PAMOs);

2) The mitigation measures to be applied; and

3) The mitigation actions to be implemented, should a marine mammal be detected.

## 4.1 Dedicated observers (MMOs and PAMOs)

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

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

It is recommended that:

• MMOs conduct daylight observations from half an hour before sunrise to half an hour after sunset;

• Fatigue and effective watch-keeping be managed by limiting watches to a maximum of 4 hours; and

• The maximum on-duty shift duration must not exceed 12 hours in any 24-hour period.

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

It is recommended that:

• Where possible, both MMOs are on watch during pre-start observations and soft starts;

• While in transit to the prospect the observers deliver a presentation to crew members detailing observer roles and mitigation requirements;

• The observers hold briefings with key personnel prior to the commencement of seismic operations; and

• The observers provide posters detailing mitigation procedures and communications protocols and display these in the instrument room, at the PAM station and on the Bridge (refer Addenda 1, and Addenda 2).

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

### 4.1.1 Safety drills

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

### 4.1.2 PAM not operational

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

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

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

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

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

It is recommended that MMOs and PAMOs familiarise themselves with this revision to the Code, including the conditions. For clarity, the period that a survey may operate without PAM is a maximum of 2 hours 20 minutes and only when the conditions identified in Section 4 1.2 of the 2013 Code are satisfied. Once this time is exceeded, the source must be shut down until PAM is operational again.

## 4.2 Crew observations

As per Section 3.8.6 of the Code:

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

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

## 4.3 Mitigation procedures

The proponent will observe the following mitigation practices:

### 4.3.1 Operational Area

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

### 4.3.2 Operational capacity

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

### 4.3.3 Sighting conditions

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

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

**Beaufort 3**

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

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

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

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

3 DOC (25 March 2014): "qualified observer should be able to monitor this via a dedicated screen as described in section 3 above"

## Beaufort 4

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

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

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

### 4.3.4 Transit

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

Woodside has committed to a MMO being on watch and recording marine mammal sightings during daylight hours and good weather during transit from the Vulcan Operational Area (Taranaki Basin) to the Toroa Operational Area.

### 4.3.5 Outline of mitigation procedure

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

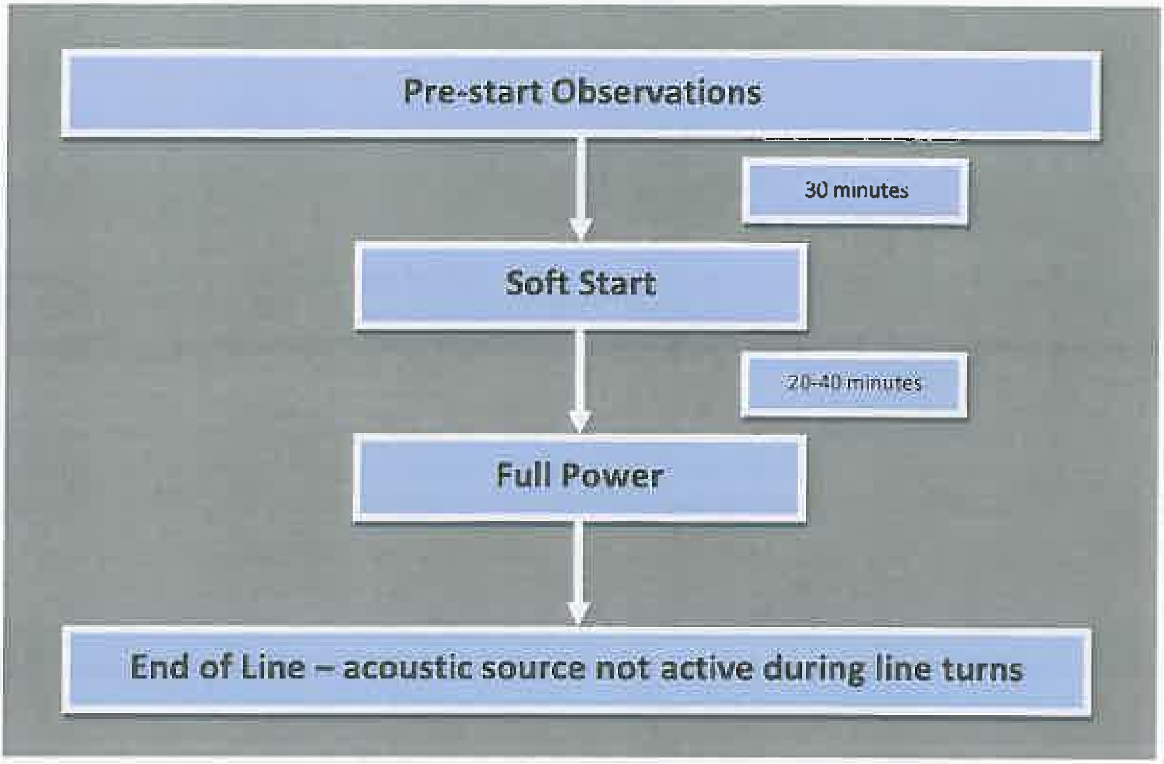



Figure 2: Seismic operations mitigation procedure.

### 4.3.6 Pre-start observations

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

The source cannot be activated during daylight hours unless:

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

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

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

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

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

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

- MMOs have undertaken observations within 20 nautical miles of the planned start up position for at least the last 2 hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than 2 hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if[4]:
    - PAM monitoring has been conducted for 2 hours immediately preceding proposed operations, and
    - Two MMOs have conducted visual monitoring in the 2 hours immediately preceding proposed operations[5], and
    - No Species of Concern have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 2 hours immediately preceding proposed operations, and
    - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed operations, and
    - No other marine mammals have been sighted during visual monitoring or detected during acoustic monitoring in the relevant mitigation zones in the 30 minutes immediately preceding proposed operations.

It is recommended that MMOs and PAMOs familiarise themselves with this revision to the Code including the conditions.

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

### 4.3.7 Soft starts

The soft start procedure will be followed every time the source is activated. That is: the gradual increase of the source's power to the operational power requirement over a period of at least 20

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

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

minutes and no more than 40 minutes, starting with the lowest power acoustic source in the array. The MMIA for the survey (Section 2.3.2.3) describes the soft start procedures to be conducted as:

*"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 capacity defined in this MMIA (4,400 in$^3$) is not to be exceeded during the soft start period."*

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

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

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

### 4.3.8 Acoustic source testing

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

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

### 4.3.9 Line turns

There will be no acquisition during line turns and the acoustic source will not be active (unless soft start procedures are in effect).

## 4.4 Species of Concern

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

## 4.5 Mitigation zones

The Code stipulates standard mitigation zones for Level 1 surveys. These will be applied during the survey and are outlined below:

1) 1.5 km from the centre of the acoustic source for SOC with calf;
2) 1.0 km from the centre of the acoustic source for SOC without calf; and
3) 200 m from the centre of the acoustic source for all other marine mammals.

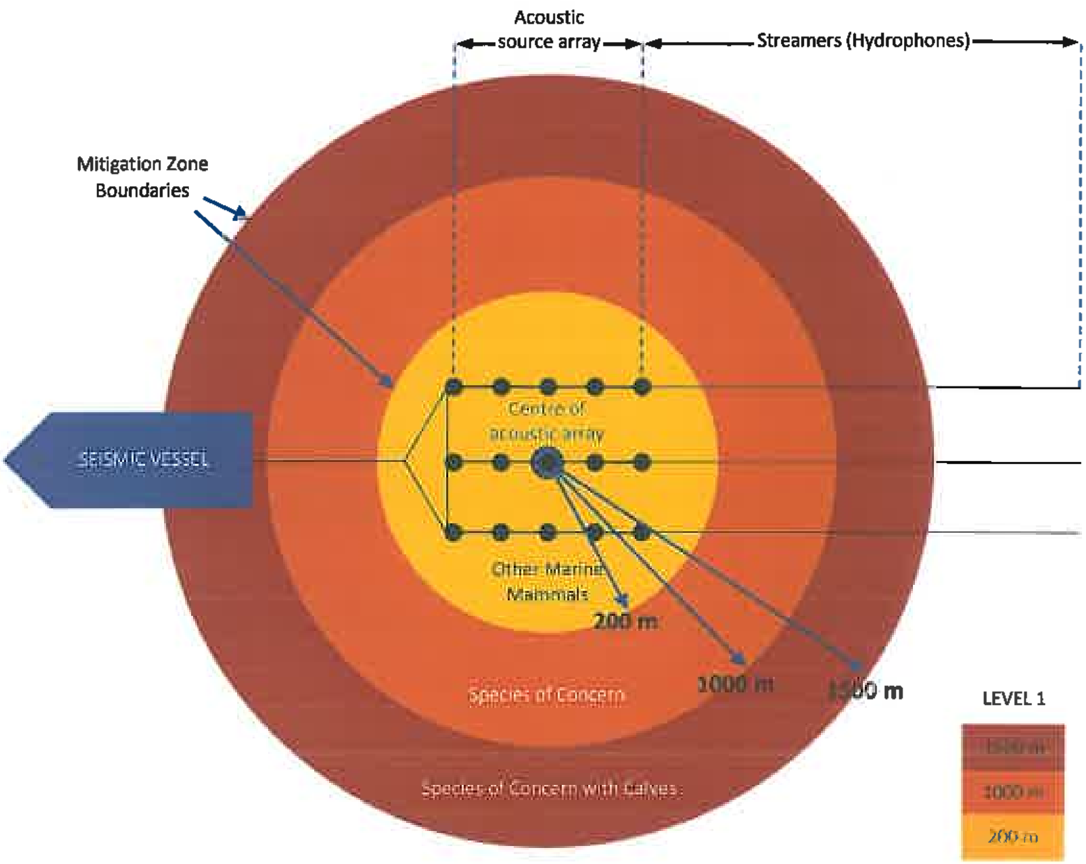



Figure 3: Mitigation Zone Boundaries for the survey as outlined in the Code.

### 4.5.1 PAM and calves

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

PAMOs must be familiar with this requirement

## 4.6 Mitigation actions

In the event that marine mammals are detected by the observer within the designated mitigation zones (**1.5 km, 1.0 km** and **200 m),** the observer will either delay the start of operations or shut down the source. These mitigation actions will apply to:

### 4.6.1 Species of Concern with calves

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

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

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

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

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

### 4.6.2 Species of Concern without calves

If during pre-start observations or when the acoustic source is active (including soft starts) the observer (MMO or PAMO) detects a SOC (without calf) within 1.0 km of the source, start-up will be delayed, or the source will be shut down and not reactivated until:

1) The observer confirms the SOC has moved to a point that is more than 1.0 km from the source; or
2) Despite continuous observation, 30 minutes has elapsed since the last detection of the SOC within 1.0 km of the source, and the mitigation zone remains clear.

It is a requirement that due to the range limitations of PAM, all acoustic detections of cetaceans using ultra high frequency vocalisations (e.g. Māui or Hector's dolphins) trigger an immediate shutdown of an active survey or delay the start of operations unless a MMO confirms that vocalisations do not emanate from such a SOC. This is because the maximum effective detection range of ultra-high frequency vocalisations from the PAM equipment under these general operational conditions (i.e. background noise levels) is in the order of 300-400 m.

### 4.6.3 Other Marine Mammals

If, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200 m of the source, start-up will be delayed until:

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

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

---

6 Email to BPM from DOC Senior Adviser - International and Marine; 17 December 2012.

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

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

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

### 4.6.4 Mitigation posters and summary

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

## 5. Further Mitigation and Reporting Measures

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

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

   The results of STLM indicate that implementing the standard mitigation zones as outlined in the Code was appropriate. During the survey, the results of the STLM will be validated.

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

   During transit from the Vulcan Operational Area (Taranaki Basin) to the Toroa Operational Area, a MMO will be on watch and recording marine mammal sightings. Any marine mammal sightings outside the Operational Area will be recorded in the standardised DOC Off Survey Reporting form.

3) **Additional requirements for start-up in a new location in poor sighting conditions**

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

4) **Necropsy of stranded marine mammals**

   If any marine mammals are stranded or washed ashore during or within two weeks after the survey and inshore of the Operational Area, a discussion between DOC and Woodside will occur to determine where the seismic vessel had been operating and whether a necropsy will be undertaken. DOC will be responsible for all aspects of the necropsy and coordination with pathologists at Massey University in order to determine the cause of death and whether it was a result of any pressure-related or auditory injuries, Woodside will consider covering the costs directly associated with Massey University undertaking a necropsy.

5) **Notification of any marine mammal carcass observed at sea**

   If a marine mammal carcass is observed at sea during the survey, the location and species (where possible) and any other useful information will be recorded and the lead MMO will notify and provide this information to DOC at the earliest opportunity.

# 6. Notifications to DOC

If a situation arises that requires a more direct line of communication from the observers to DOC, then the MMO Team Leader is to first inform the Party Chief of the issue and intended action. The following table summarises the situations when DOC (in effect, the Director-General) should be notified immediately. During this survey, the first point of contact within DOC i . If a response is required urgently then telephone, but in all other circumstances use email. Should Ian Angus be unavailable, please phone 0800DOCHOT and state the information as outline in Section 3.3.

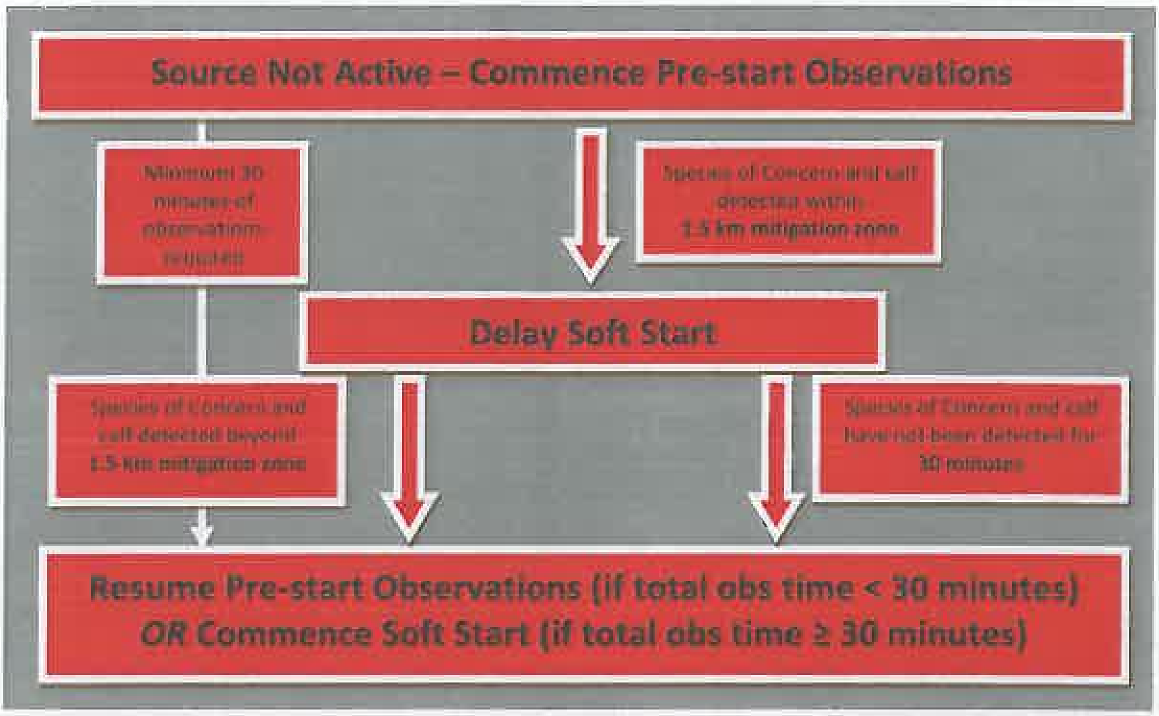
Table 1: Events that require DOC to be notified.

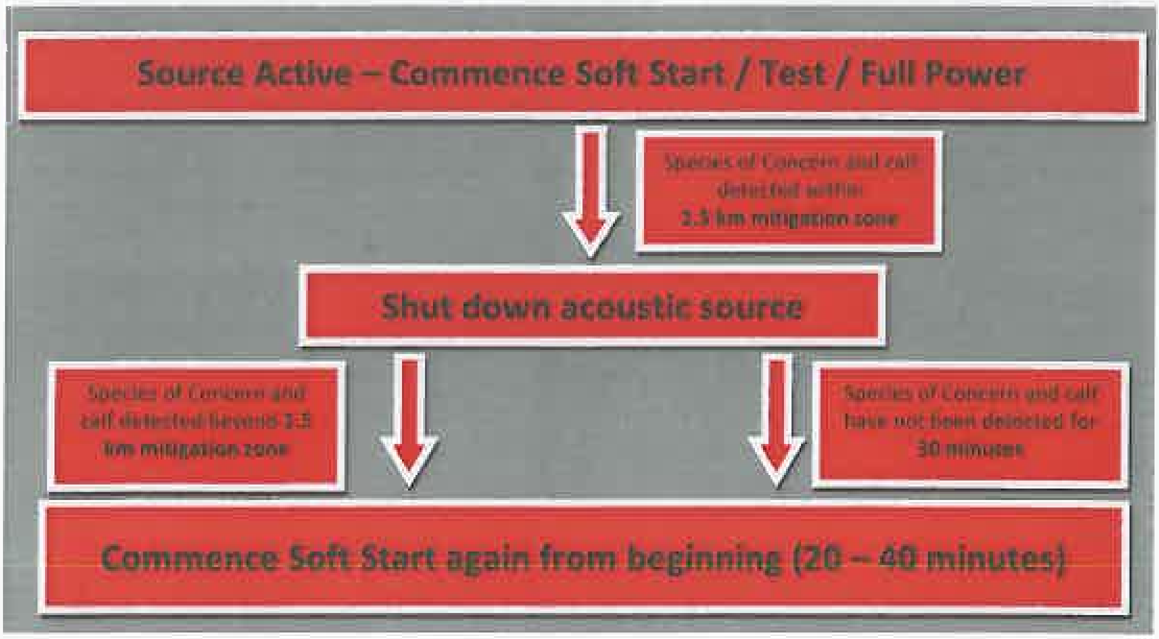
| Situation | Timing of notification | Comments |
|---|---|---|
| The PAM system becomes non-operational | Immediate | This refers to when both primary and backup systems are non-operational |
| Any instances of non-compliance with the Code | Immediate | This is a standard requirement under the Code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

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

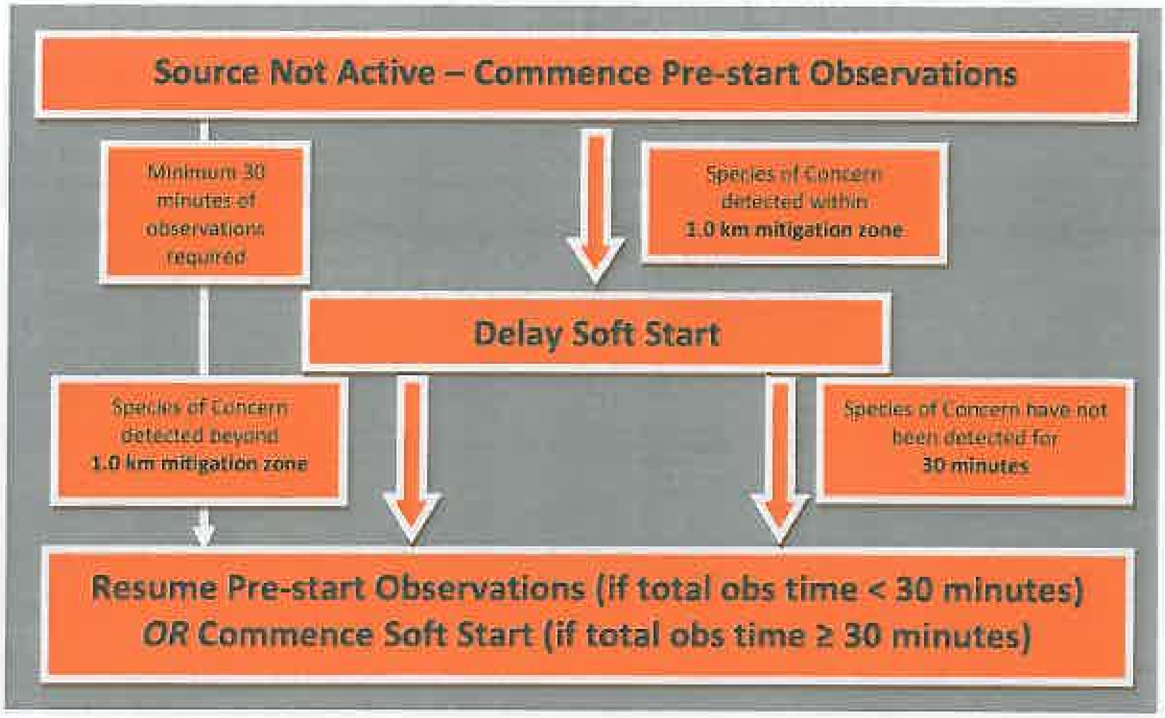
The following posters depict mitigation procedures. It is recommended they be posted in the instrument room, the PAM station and on the bridge. Operational flowcharts are also found in Appendix 4 of the Code.

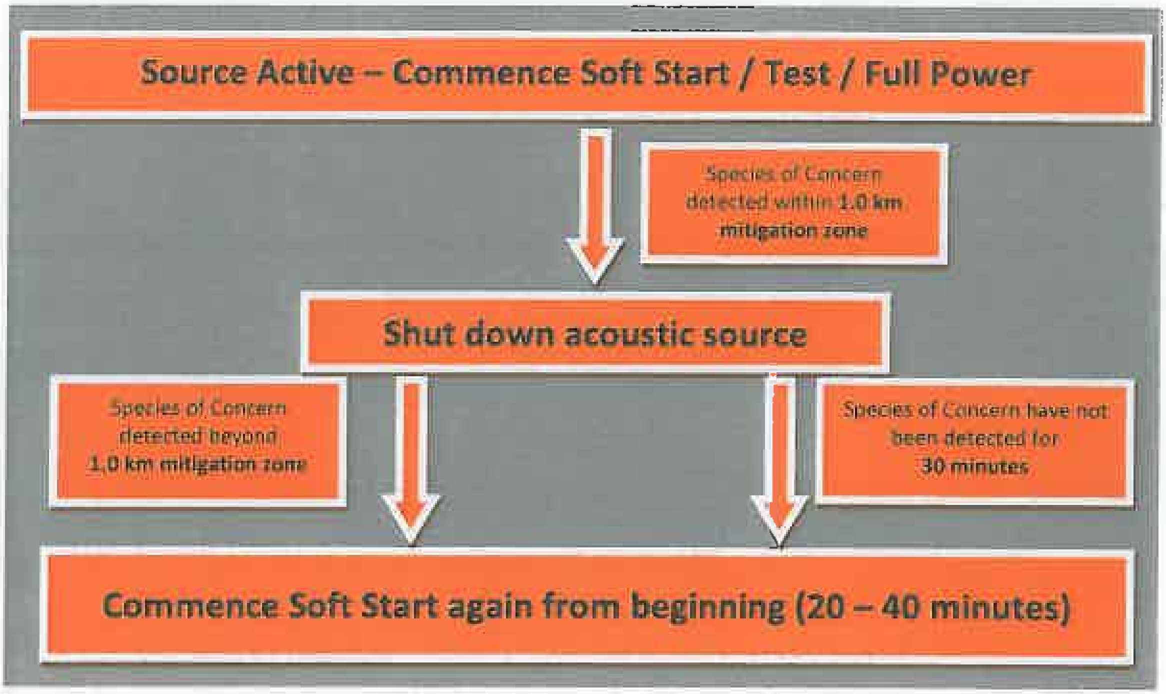
### Species of Concern with Calves within 1.5 km of Acoustic Source



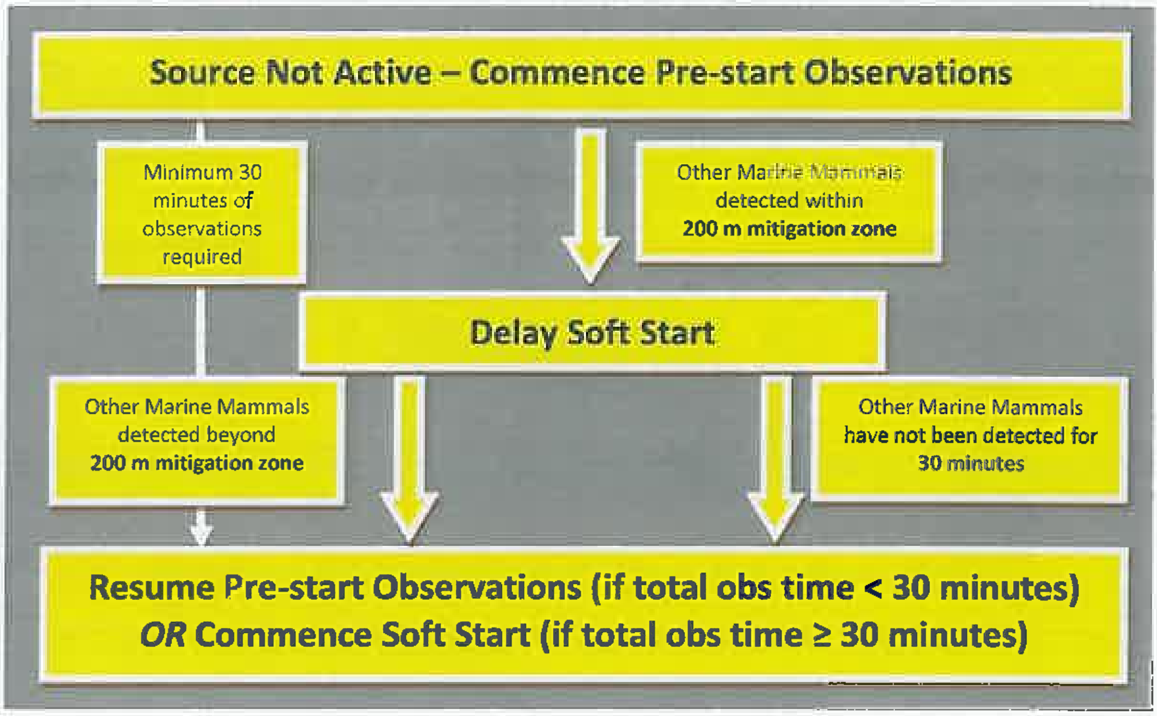



# STANDARD MITIGATION ZONES
## Species of Concern (no Calves) within 1.0 km of Acoustic Source

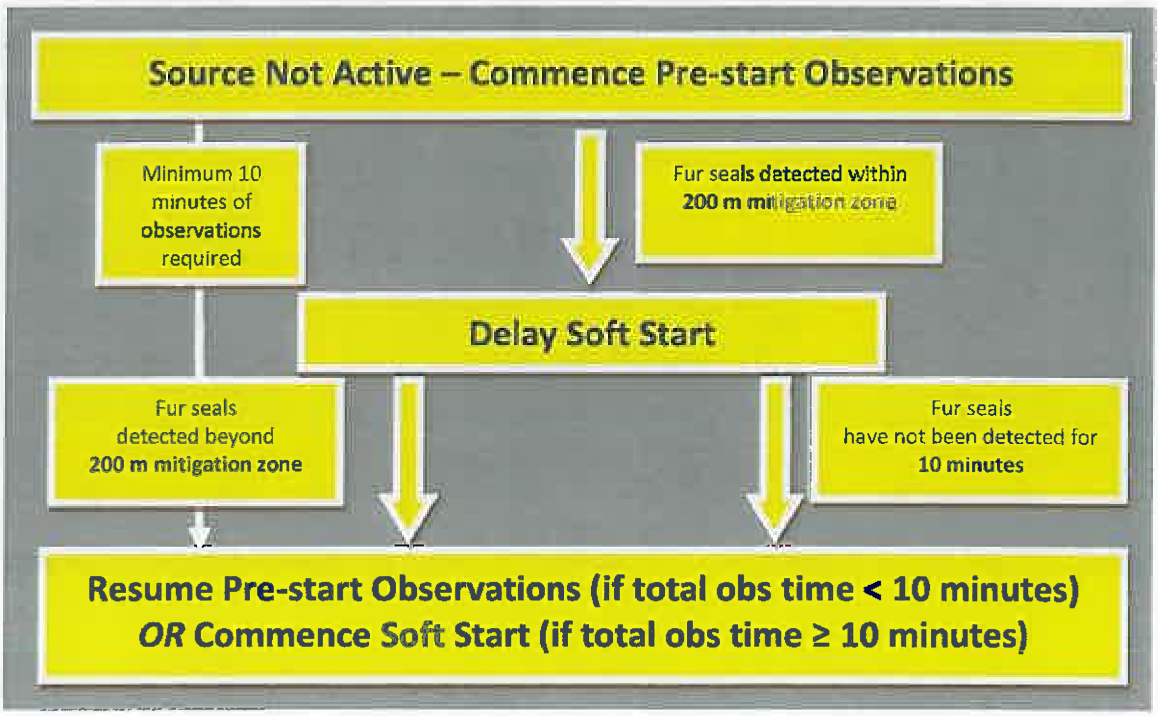


# Other Marine Mammals within 200 m of Acoustic Source (excluding fur seals)




# Fur seals within 200 m of Acoustic Source



# Addenda 2: Recommended Communication Protocols (poster format)

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

## Normal Operations - No Marine Mammal Sighting/Detection

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

↓

**Prior to soft start, seismic call observers for ALL CLEAR**

↓

**Seismic notify observers time of soft start**

↓

**Seismic call observers to confirm time of full power**

↓

**Seismic notify observers time of end of acoustic source shutdown**

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

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

**Pre-start observations** | **Soft Start** | **Full power acquisition**

↓

**Observers detect:**

**SOC with calf approaching 1.5 km mitigation zone *OR***
**SOC approaching 1.0 km mitigation zone *OR***
**Other Marine Mammals approaching 200 m mitigation zone***
***Only applies to pre-start observations**

↓

**Observers notify seismic to go on standby**

↓

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

**SOC with calf within 1.5 km *OR***
**SOC within 1.0 km *OR***
**Other Marine Mammals within 200 m mitigation zone**

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

**SOC with calf within 1.5 km**
***OR***
**SOC within 1.0 km mitigation zone**

↓

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

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

↓

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

# Addenda 3: Operational Area coordinates

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

| Operational Area (WGS84) | |
|---|---|
| Longitude (decimal degrees West) | Latitude (decimal degrees South) |
| 169.5481323 | -47.9816629 |
| 169.2842819 | 47.8715532 |
| 169.6270279 | -47.4984364 |
| 170.5440723 | -47.8753463 |
| 170.2723428 | -48.1770836 |
| 170.2723428 | -48.0284547 |
| 169.5208915 | -48.4471948 |
| 169.2914861 | -48.3523334 |
| 169.6111761 | -48.0078145 |
| 169.5979201 | -48.0023208 |
| 169.5481323 | -47.9816629 |

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

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

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

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

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

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

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

# APPENDIX 5

## Sound Transmission Loss Modelling

Curtin University

## Centre for Marine Science and Technology

# Received underwater sound level modelling for the Toroa 3D seismic survey

Prepared for:

Environmental Offshore Services Ltd

Prepared by: Marta Galindo-Romero and Alec Duncan

PROJECT CMST 1323
REPORT 2014-42

3rd September 2014

## Summary

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from the Toroa 3D seismic survey operations within New Zealand permit area PEP 55794 (Great South Basin).

Both short range and long range modelling were carried out. The modelling method used to produce the short range results accurately deals with both the horizontal and vertical directionality of the seismic source. The method used for computing the long range results only considers the horizontal directionality of the array but accounts for water column and seabed variations in depth and range.

The modelled seismic source was a 3460 cubic-inch airgun array at a depth of 7m.

The short range modelling predicted that the maximum sound exposure levels would be below the Code of Conduct thresholds of 186 dB re 1 $\mu Pa^2$.s at 200 m and 171 dB re 1 $\mu Pa^2$.s at 1 and 1.5 km.

The long range modelling results were highly directional due to the combined effects of seismic source directionality, bathymetry, and seabed properties. Levels showed high attenuation inshore of the source in the in-line direction, and slow attenuation offshore and in the cross-line direction. Maximum levels at the outer boundary of the Catlins Coast Marine Mammal Sanctuary due to a source in 630m water depth, in the northern corner of the operational area, were predicted to be lower than 90 dB re 1 $\mu Pa^2$.s.

## Contents

## List of Figures

# 1 Introduction

This report describes acoustic propagation modelling which was carried out to predict the underwater sound levels that are likely to be produced by the Toroa 3D seismic survey in New Zealand permit area PEP 55794. The aims of the modelling were to establish whether the survey will meet the sound exposure level requirements of the New Zealand Department of Conservation 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations, and to predict the maximum sound exposure levels in the Catlins Coast Marine Mammal Sanctuary. The Code requires modelling to determine whether received sound exposure levels will exceed 186 dB re 1 $\mu Pa^2.s$ at a range of 200m from the source, or 171 dB re 1 $\mu Pa^2.s$ at ranges of 1km and 1.5km.

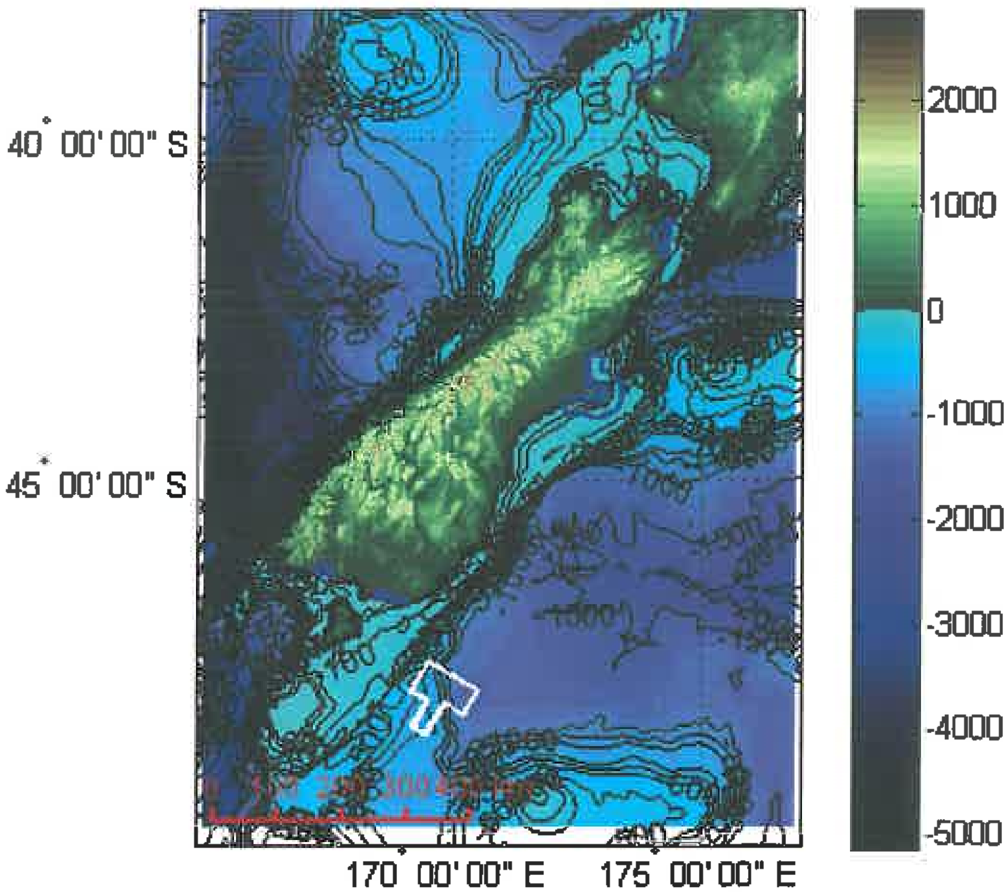



Figure 1. Map of the New Zealand South Island showing the survey area. The white polygon shows the bounds of the operational area. The dark blue line shows the boundaries of various marine mammal sanctuaries.

The operational area where the survey takes place is displayed in Figure 1 with a white polygon. The boundaries of various marine mammal sanctuaries are also plotted. This area is located within the Great South Basin, and extends from the coast of Otago-Southland, to Stewart Island and the Campbell Plateau, limited by the Pukaki Rise and from there to deeper waters of the Bounty Trough. The bathymetry data shown in Figure 1 was obtained from the NIWA elevation and bathymetry grid (CANZ 2008).
This report is organised as follows: Section 2 describes the methods used to carry out the modelling, and the results are presented in Section 3. Major conclusions are summarised in Section 4.

# 2 Methods

## 2.1.1 Source modelling

The seismic source proposed for this survey is the 3460 cubic-inch airgun array shown in Figure 2. The source depth is 7 m.

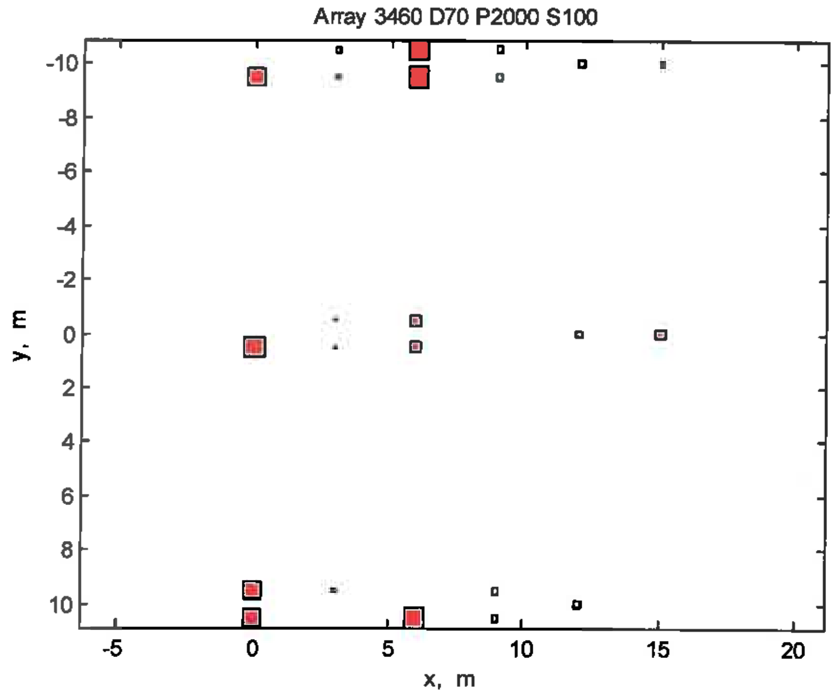



Figure 2. Plan view of the 3460 cubic-inch array. Array elements are shown much larger than actual size but are scaled proportional to the cube root of their volume.

### 2.1.2 Modelling and calibration methods

Acoustic signals required for this work were synthesised using CMST's numerical model for airgun arrays. The procedure implemented for each individual source element is based on the bubble oscillation model described in Johnson (1994) with the following modifications:

- An additional damping factor has been added to obtain a rate of decay for the bubble oscillation consistent with measured data;
- The zero rise time for the initial pressure pulse predicted by the Johnson model has been replaced by a finite rise time chosen to give the best match between the high frequency roll-off of modelled and measured signal spectra;
- For the coupled-element model used in this work, the ambient pressure has been modified to include the acoustic pressure from the other guns in the array and from the surface ghosts of all the guns. Including this coupling gives a better match between the modelled signal and example waveforms provided by seismic contractors, but only has a minor influence on the spectrum of this signal and hence on the modelled received levels.

The model is subjected to two types of calibration:

- The first is historical and was part of the development of the model. It involved the tuning of basic adjustable model parameters (damping factor and rise time) to obtain the best match between modelled and experimentally measured signals, the latter obtained during sea trials with CMST's 20 $in^3$ air gun. These parameters have also been checked against several waveforms from larger guns obtained from the literature.
- The second form of calibration is carried out each time a new array-geometry is modelled, the results of which are presented below. Here, the modelled gun signals' amplitudes are scaled to match the signal energy for a far-field waveform for the entire array computed for the direction (including ghost) to that of a sample waveform provided by the Client's seismic contractor. When performing this comparison the modelled waveform is subjected to filtering similar to that used by the seismic contractor in generating their sample, or additional filtering is applied

to both data sets to emphasise a section of the bandwidth of the supplied data which CMST regards as being most reliable.

Beam patterns for the calibrated array were built up one azimuth at a time as follows:

- The distances from each gun to a point in the far-field along the required azimuth were calculated. (The far-field is the region sufficiently far from the array that the array can be considered a point source);
- The corresponding time delays were calculated by dividing by the sound speed;
- Computed signals for each gun were delayed by the appropriate time, and then these delayed signals were summed over the guns;
- The energy spectral density of the resulting time domain waveform was then calculated via a Fourier transform;
- During this procedure care was taken to ensure that the resulting spectrum was scaled correctly so that the results were in source energy spectral density units: dB re 1 $\mu Pa^2 s/Hz$ @ 1m.

### 2.1.3 Source modelling results

Figure 3 show comparisons between the example waveforms and spectra for the vertically downward direction provided by the client and those produced by the CMST airgun model after calibration. There are differences in detail but the general agreement is good.

In this case the provided example waveforms were for an array depth of 7 m, the same as the expected operational depth.

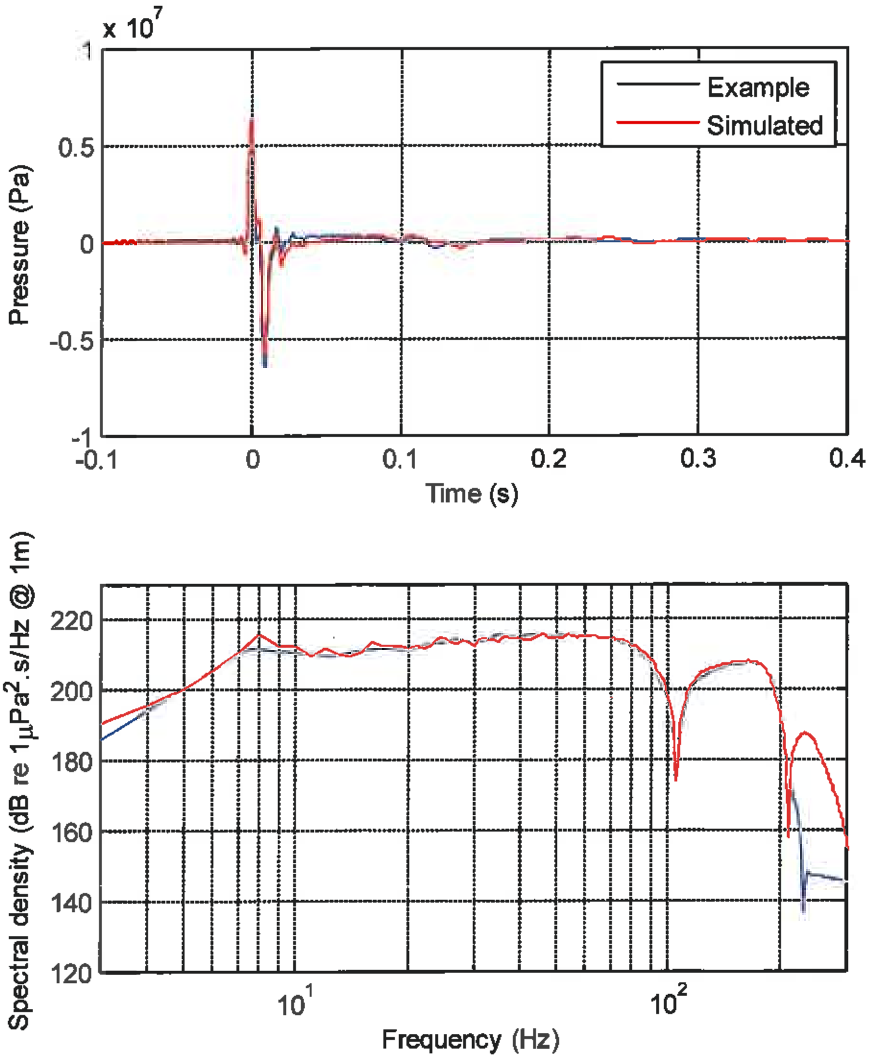



Figure 3. Comparison between the waveforms (top) and spectra (bottom) for the 3460 cubic-inch Bolt Array. The example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).

Vertical and horizontal cross-sections through the frequency dependent beam pattern of the array are shown in Figure 4. These beam patterns demonstrate the strong angle and frequency dependence of the radiation from the airgun arrays. The horizontal beam pattern shows that in the horizontal plane a large amount of the high frequency energy is radiated in the cross-line direction and a significant amount of energy is also radiated in the in-line direction. These beam patterns are characteristic of an seismic source with wide spacing between elements or in this case wide spacing between sub-arrays.

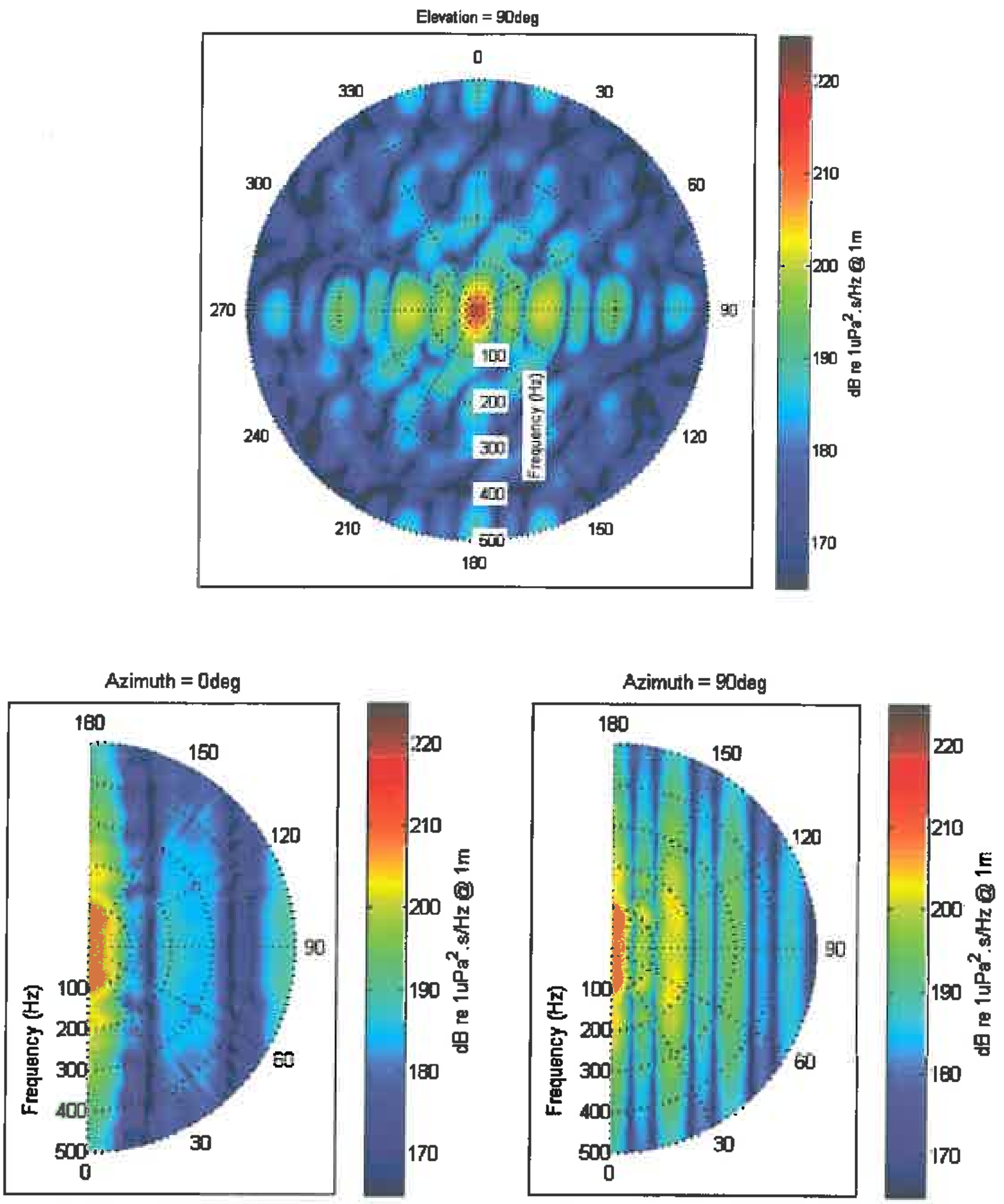



Figure 4. Array far-field beam patterns as a function of orientation and frequency. The top plot is for the horizontal plane with 0 degrees azimuth corresponding to the in-line direction. The bottom two plots are for the vertical plane for the in-line direction (left) and cross-line direction (right). Zero elevation angle corresponds to vertically downwards.

### 2.1.4 Propagation modelling

#### 2.1.4.1 Water-column properties

The appropriate Autumn (April-June) sound speed profile from the World Ocean Atlas (Locarnini et al., 2006) (Antonov, Locarnini, Boyer, Mishonov, & Garcia, 2006) was chosen for this modelling work in order to capture the worst-case conditions that could be encountered towards the end of the survey. Full water depth autumn sound speed profiles for three of the geoacoustic regions defined for this survey (see next section) are shown in Figure 5.

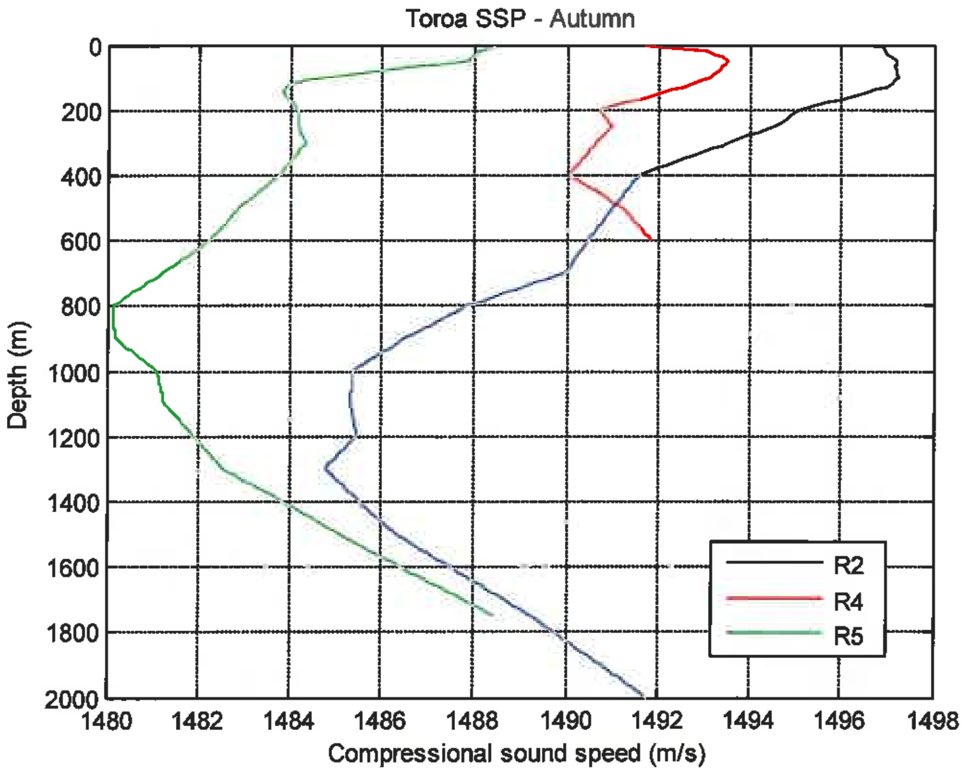



Figure 5. Sound velocity profiles obtained from NOAA World Ocean Atlas.

#### 2.1.4.2 Regional geoacoustic models & bathymetry

Since the survey spans an area of complex bathymetry, five geoacoustic regions representing different bottom types were used. These regions are shown in Figure 6. The regions were chosen to represent the probable bottom sediment compositions and sub-bottom layering. The bottom models for each region were based on information from published literature on New Zealand regional seabed geology. However this information is very limited for this area, which will limit the accuracy of the modelling results.

In general, except for one region (R2), elastic propagation parameters were ignored. When limited information is known about sediments and the average sediment composition consists of sand, silt, and clay, neglecting elastic effects is a reasonable approximation (Jensen, Kuperman, Porter, & Schmidt, 2011). For the region R2 an equivalent fluid bottom was used rather than an elastic bottom, which is a reasonable approximation for long range propagation.

The resulting seabed properties for each geoacoustic region are tabulated below in Table 1.

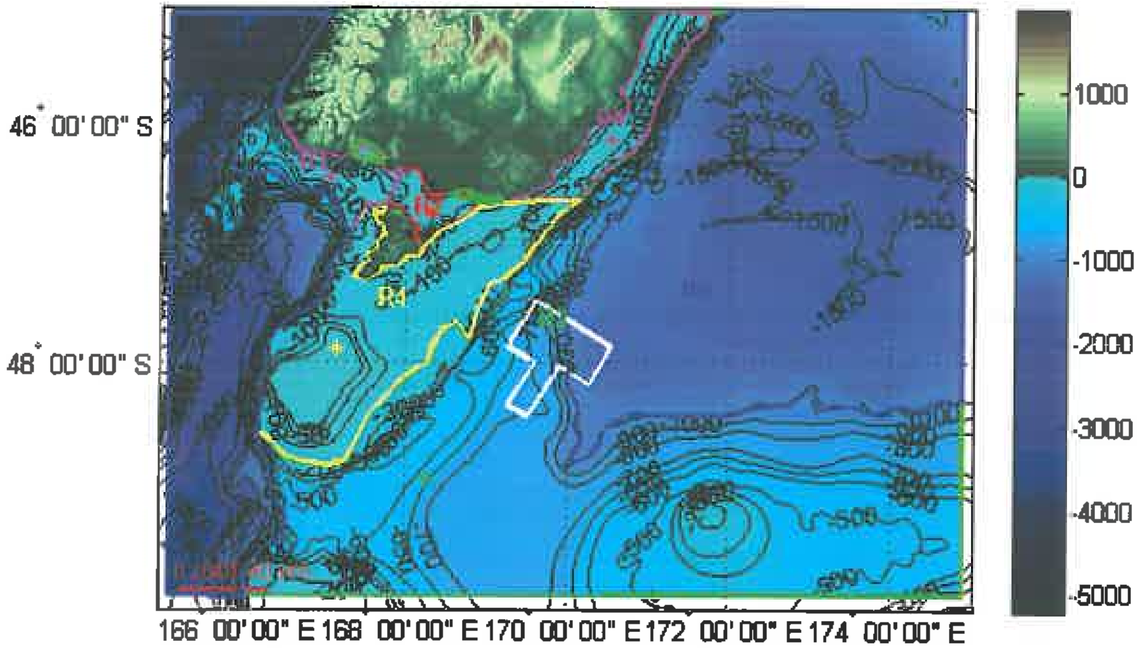



Figure 6. Geoacoustic regions for the Toroa survey region. The white polygon shows the bounds of the operational area. The boundary of the Catlins Coast Marine Mammal Sanctuary is plotted in green.

Table 1: Geoacoustic Properties for the regions in defined in Figure 6.

| Layer Sediment Description | Thickness (m) | ρ (kg.m$^{-3}$) | $c_p$ (m.s$^{-1}$) | | $\alpha_p$ (dB/λ) | |
|---|---|---|---|---|---|---|
| **R1: Otago and Southland Shelf region** | | | | | | |
| Fine Sand | 30 | 1941 | 1749 | | 0.7 | |
| | | 1986 | 1794 | | | |
| Halfspace sand | N/A | 1986 | 1794 | | 0.7 | |
| **R2: Foveaux Strait** | | | | | | |
| Fine Sand | 20 | 1962 | 1759 | | 0.8 | |
| | | 2034 | 1836 | | | |
| Halfspace Coarse sand | N/A | 2034 | 1836 | | 0.8 | |
| **R3: Campbell Plateau & Otago Slope Region** | | | | | | |
| Silt – Clay Layer | 150 | 1488 | 1549 | | 0.1 | |
| | | 1662 | 1733 | | | |
| Silt – Clay Half Space | N/A | 1662 | 1733 | | 0.1 | |
| **R4: Southern Shelf – Snares Islands** | | | | | | |
| | | | $c_p$ (m.s$^{-1}$) | $c_s$ (m.s$^{-1}$) | $\alpha_p$ (dB/λ) | $\alpha_s$ (dB/λ) |
| Carbonate sediment half space | N/A | 1900 | 2100 | 550 | 0.1 | 0.2 |
| Equivalent Fluid Half Space | N/A | 1900 | 2290 | 0.0 | 7.6 | 0.0 |
| **R5: Deep water region of Bounty Through and Western Region** | | | | | | |
| Pelagic Mud - Ooze | 400 | 1435 | 1556 | | 0.47 | |
| | | 1900 | 2156 | | | |
| Halfspace | N/A | 1900 | 2156 | | 0.47 | |

**Symbol key for Table 1:**
**ρ = density, $c_p$ = compressional wave speed, $c_s$ = shear wave speed, $\alpha_p$ = compressional wave attenuation, $\alpha_s$ = shear wave attenuation, λ = wavelength**

The region R1 comprises the continental shelf of Otago, and also the Southland shelf except the Foveaux Strait. The sediment cover of the Canterbury-Otago shelf is mainly made of near shore modern terrigenous sand, biogenic and relict sands on the middle shelf and biogenic sands right before the slope, similar to the Waikato-Taranaki shelf. These sands on the Otago shelf are characterised by the high presence of metamorphic rock fragments and minerals from the Otago Schists (Carter, 1975). This region R1 was thus modelled as a layer of fine sand over a sandy halfspace with the acoustic parameters listed in Table 1.

The region R2 covers the Foveaux Strait, between Southland and Stewart Island. This area is characterised by bottom sediments mainly consisting of are gravels and sandy gravels (Cullen, 1966). The acoustic properties of a sandy gravel bottom were approximated by a halfspace of coarse sand, covered by a thin layer of fine sand, as a continuation of the rest of the shelf.

The region R3 is extended along the main area of the Campbell Plateau, and also the continental slope of Otago-Southland. Near Campbell and Bounty Islands, and at petroleum wells Kawau-1A, Hoio-1C, and Rakiura-1, quartz-rich metasedimentary rocks are predominant (Beggs, Challis, & Cook, 1990). Measurements of velocity and thickness of layers from the sonobuoy 1E37 on the seismic profile E37 (Davey, 1977) revealed a layer with an average sound speed of 1700 m/s, followed by a layer with an average sound speed of 2300 m/s. For this model, and with all the information collected, a layer of 150 m depth of silt-clay with a gradient in velocity over a halfspace was considered appropriate to represent the acoustic properties of the region R3.

The region R4 occupies the southern area of the continental shelf of New Zealand South Island. The southern shelf is an area of high percentage of calcium carbonate surficial sediments (Nelson, Keane, & Head, 1988) and basements of granitic rocks in the extension from Auckland Island to exploration wells Pakaha-1, Tara-1, and Pukaki-1, and south of Stewart Island (Beggs et al., 1990). Data of velocity and thickness of layers from the sonobuoy 5E40 on the seismic profile E40 (Davey, 1977) were used as reference, but there is insufficient literature defining the geoacoustic properties of unconsolidated carbonate sediment (Hamilton, 1980). In light of this we assume the sediments in R4 are analogues or similar to the seabed geology present around coastal Australia. The geoacoustic parameters of semi-cemented calcarenite/sand as defined by Duncan, Gavrilov, McCauley, Parnum, and Collis (2013) were used for R4. A fluid bottom replaced the elastic parameters of limestone and calcarenite bottoms of R4. The properties of the fluid half space were chosen by calculating a fluid reflection coefficient and matching it as closely as possible to the solid bottom reflection coefficient. The reflection coefficient fit is shown in Figure 7. Fluid bottoms are required to facilitate the use of RAMGeo as a sound propagation code for long range modelling.

Finally, the region denoted as R5 represents the eastern region of deeper waters in the area of Bounty Trough. It was assumed a pelagic area with finer sediments, as it can be expected away from the continental shelf. Thus, as a layer of 400 m depth of pelagic mud-ooze with a gradient in velocity over a halfspace is used for the model. The same model was used to cover the western area represented in Figure 6.

With the likely bottom sediment types defined, the geoacoustic parameters for the regions were taken mainly from (Hamilton, 1970) and (Jensen et al., 2011).

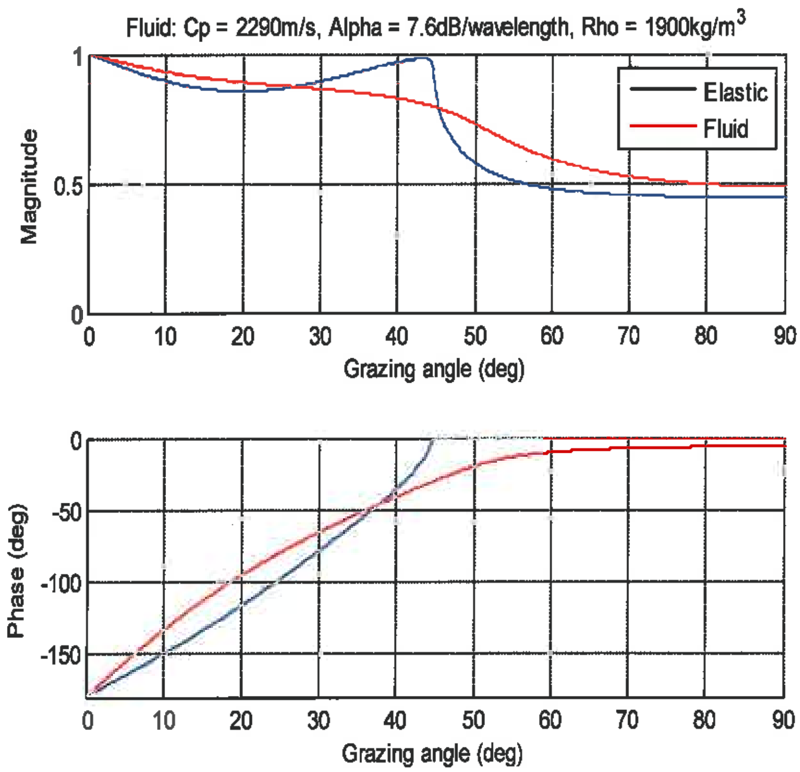



Figure 7. Equivalent fluid bottom for R4.

### 2.1.4.3 Short Range Modelling

*2.1.4.3.1 Choice of propagation modelling codes*

The short ranges involved in this component of the modelling made it possible to use the range independent propagation modelling code SCOOTER (Michael B. Porter, 2007) for this work. SCOOTER is a wavenumber integration code, which is stable, reliable, and can deal with arbitrarily complicated fluid and/or solid seabed layering. It cannot, however, deal with changes of water depth with range, and is therefore considered a range independent model, but that is unimportant in this particular application.

*2.1.4.3.2 Source Locations*

One source location S1 was used for the Toroa survey (Figure 8) at the shallowest location, and was chosen for modelling as a source in this location will produce the highest sound levels due to the contribution of seabed reflections.

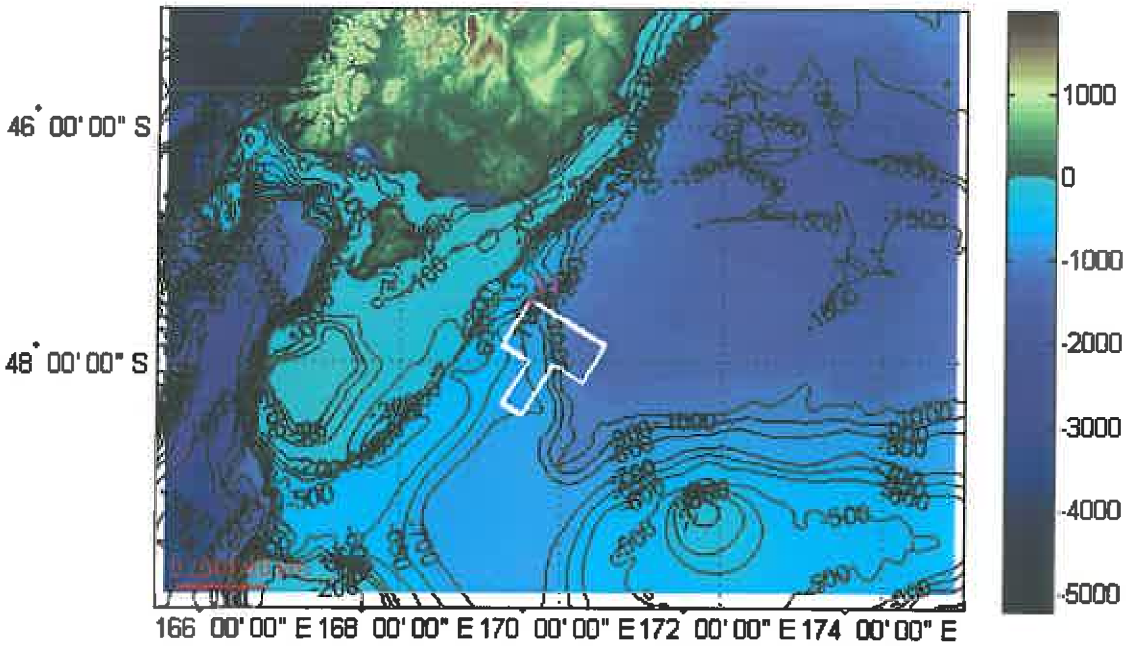



Figure 8. The magenta dot labelled S1 is the source location chosen for short range modelling. The white polygon is the boundary of the operational area.

### 2.1.4.4 Long Range Modelling

*2.1.4.4.1 Choice of propagation modelling codes*

For longer ranges the effects of varying water depth are important and it was necessary to use a range dependent model. In this case the parabolic equation code RAMGeo (Collins, 1993) was used. This code is well tested and reliable but can only deal with fluid seabeds.

*2.1.4.4.2 Long Range Source Location*

A single source location was chosen to model long range sound propagation. This source location is labelled S1 and is shown below in Figure 9. This location was chosen as being likely to produce the highest sound levels inshore of the survey area and within the Catlins Coast Marine Mammal sanctuary.

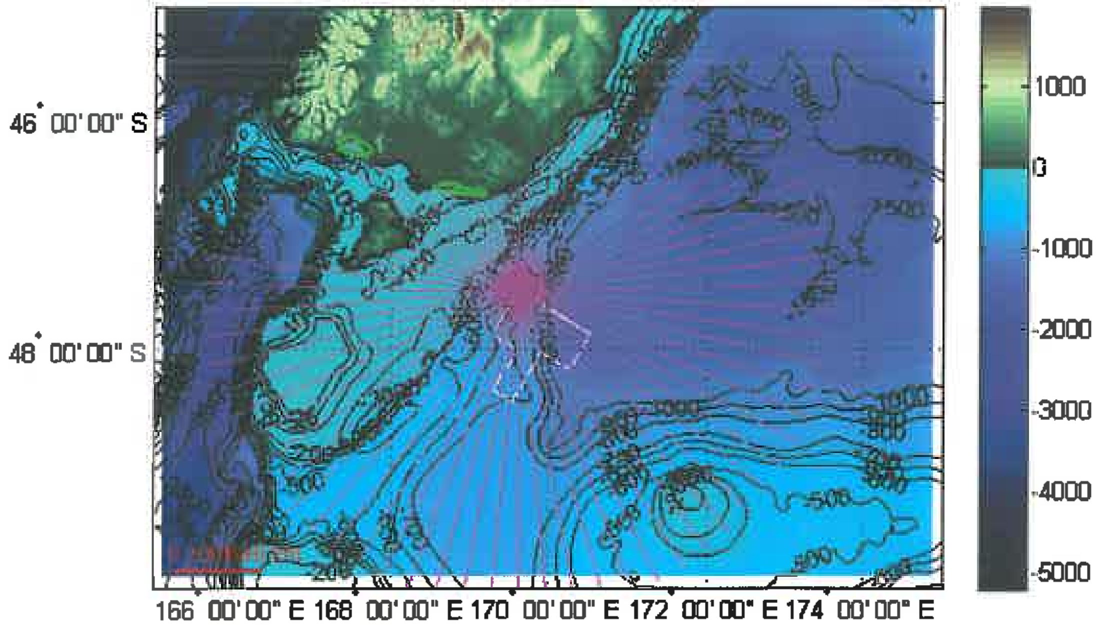



Figure 9. Geoacoustic regions, marine sanctuary area, and source location (S1) used for long-range modelling for the Toroa survey. The boundary of the Catlins Coast Marine Mammal Sanctuary is plotted in green.

### 2.1.5 Sound exposure level (SEL) calculations

#### 2.1.5.1 Short Range Modelling

At short ranges it is important to include both the horizontal and vertical directionalities of the seismic source, which requires summing the signals from the individual airguns at each receiver location. This process is accurate but very computationally demanding, and it is not feasible to apply it at ranges of more than a few kilometres.

Calculation of received sound exposure levels was carried out using the following procedure:

1. For each source location:
   a. SCOOTER was run at 1 Hz frequency steps from 2 Hz to 1000 Hz for a source depth corresponding to the maximum depth of the seismic source (7m). The output of SCOOTER at each frequency and receiver location is the ratio of the received pressure to the transmitted pressure. The ratio is a complex number and represents both the amplitude and phase of the received pressure.
2. For each receiver location:
   a. The range from the receiver to each airgun in the array was calculated, and used to interpolate the results produced by the propagation modelling code, in order to produce a transfer function (complex amplitude vs. frequency) corresponding to that receiver - airgun combination.
   b. These transfer functions were inverse Fourier transformed to produce the corresponding impulse response, which was then convolved with the signal from the appropriate airgun to give a received signal due to that gun.
   c. The received signals from all guns in the array were summed to produce a received pressure signal.

The sound exposure level (SEL) at the receiver was calculated by squaring and integrating the pressure signal.

#### 2.1.5.2 Long Range Modelling

For longer ranges the short-range modelling procedure described above was too computationally intensive to be feasible and instead SELs were calculated as a function of range, depth and azimuth from each source location as follows:

- Transmission loss was modelled different azimuth increments out to 300 km maximum range using RAMGeo (fluid Parabolic Equation model) for a set of discrete (bin-centre) frequencies at one-third octave intervals from 8 Hz to 1000 Hz. Between 0 and 146° an increment of 2° was used. Then it is gradually increased from 5° to 10° and reduced again to 5° before reaching the value 0°. The bathymetry along the track was interpolated from the CANZ (2008) dataset, and the local acoustic environment was as described previously.
- Frequency-dependent source level was obtained by integrating the horizontal plane source spectrum for the appropriate (relative) azimuth over each frequency band. (Band edges were chosen as the geometric means of adjacent frequencies.) Relative azimuths were calculated based on a survey line direction of 335°T.
- Source level and transmission loss were then combined to compute the received level as a function of range, depth and frequency. This calculation was carried out at the same azimuth increments. Corresponding transmission loss data were extracted from the closest available transect (in azimuth) used in the propagation modelling.
- Integrated squared acoustic pressure was calculated for each $1/3^{rd}$-octave spectral bin. These values were summed and converted to decibels to yield SEL.

# 3 Results

## 3.1.1 Short Range Modelling Results

Maximum received sound exposure levels at any depth are plotted as a function of range and azimuth from the source at S1 in Figure 10. The directionality of received levels in the horizontal plane is due to the directionality of the seismic source, which produces its highest levels in the cross-line and in-line directions.

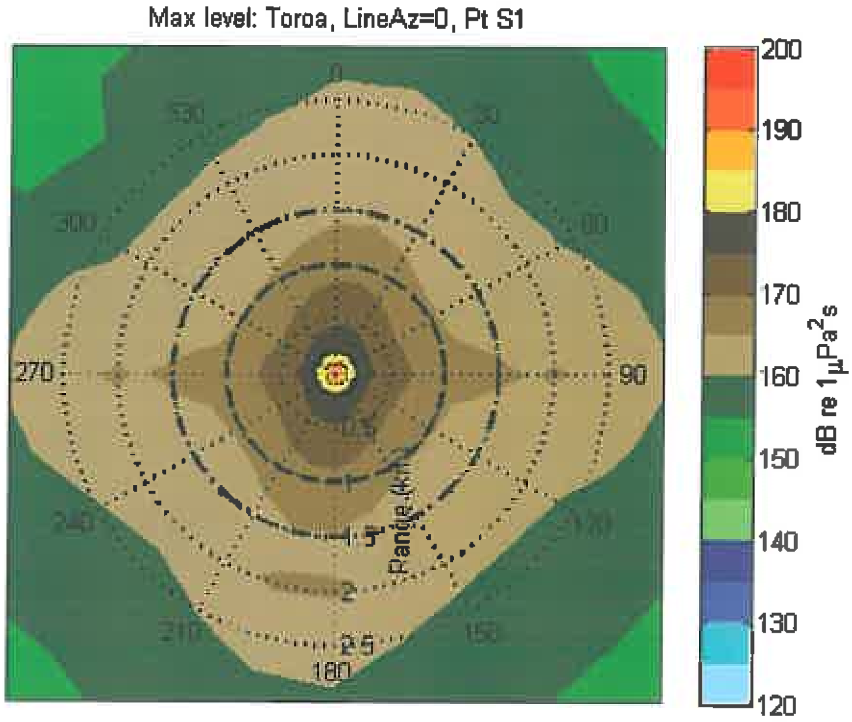



Figure 10. Predicted maximum received SEL at any depth produced as a function of azimuth and range from the source (autumn sound speed profile). An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

Figure 11 shows a point plot that displays the sound exposure levels produced by the array at S1 as a function of range. The maximum predicted sound exposure level at the specified mitigation ranges are listed in Table 2.

Figure 12 shows the percentage of shots not exceeding two thresholds as a function of range. The thresholds are limits imposed by the New Zealand Department of Conservation 2013 Code of Conduct, 171 dB re 1 $\mu Pa^2.s$ and 186 dB re 1 $\mu Pa^2.s$. It can be seen that 100 % of the shots lie below the threshold of 186 dB re 1 $\mu Pa^2.s$ at distances equal or greater than 200 m. From 700 m from the source all of them lie below 171 dB re 1 $\mu Pa^2.s$.

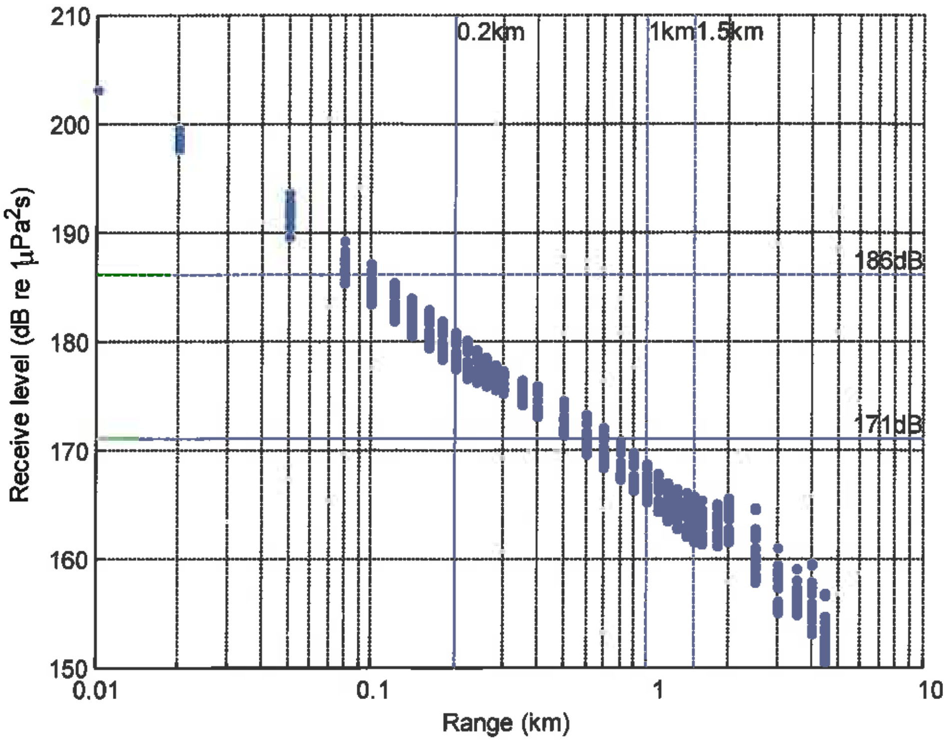



Figure 11. Scatter plot of maximum SEL at the source location S1. Points are maximum predicted received levels at any depth as a function of range, plotted for all azimuths. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 $\mu Pa^2.s$ (solid) and 186 dB re 1 $\mu Pa^2.s$ (broken).

Table 2. Maximum sound exposure levels as a function of range from source location S1 PEP 55794 (Toroa)

| Range | Maximum Sound Exposure Level (dB re 1 $\mu Pa^2.s$) |
|---|---|
| 200m | 180.8 |
| 1.0 km | 168.7 |
| 1.5 km | 165.7 |

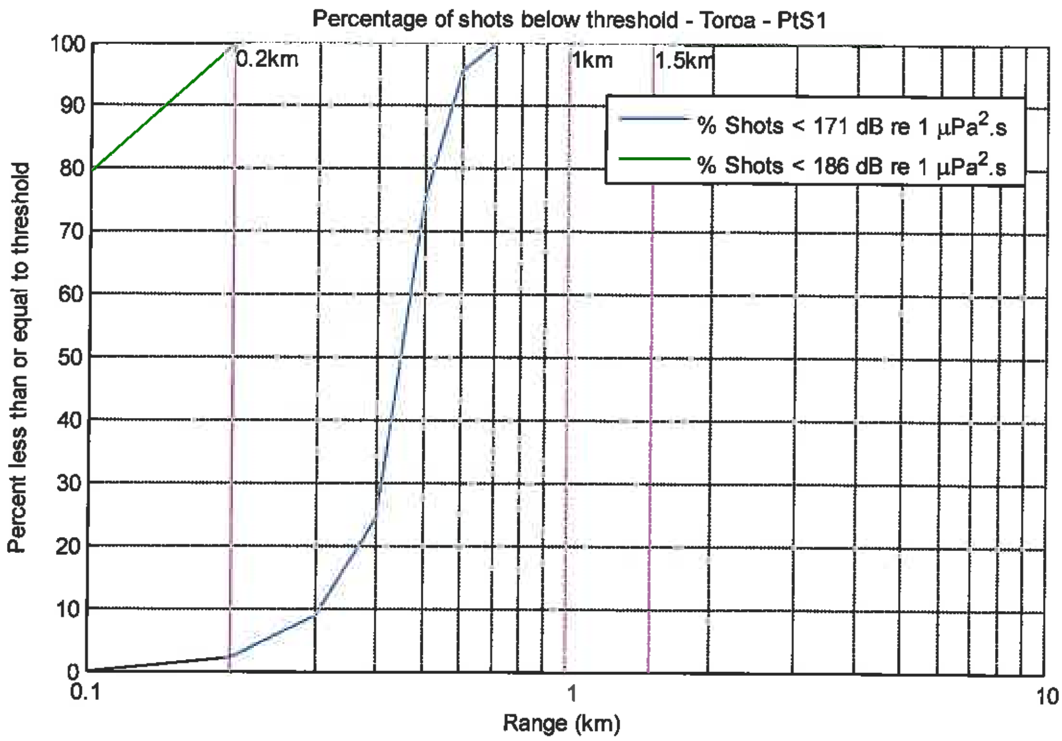



Figure 12 Percentage of shots not exceeding two thresholds as a function of range.

### 3.1.2 Long Range Modelling Results

Figure 13 shows the geographical distribution of received sound exposure levels out to a maximum range of 300 km from source location S1, which is in 630m of water. Note that in order to illustrate the lower sound levels that occur at longer ranges a different colour scale has been used for these plots than for the short range results given in the previous section. Maximum levels at the outer boundary of the Catlins Coast Marine Mammal Sanctuary for a source at S1 are predicted to be lower than 90 dB re 1 $\mu Pa^2.s$.

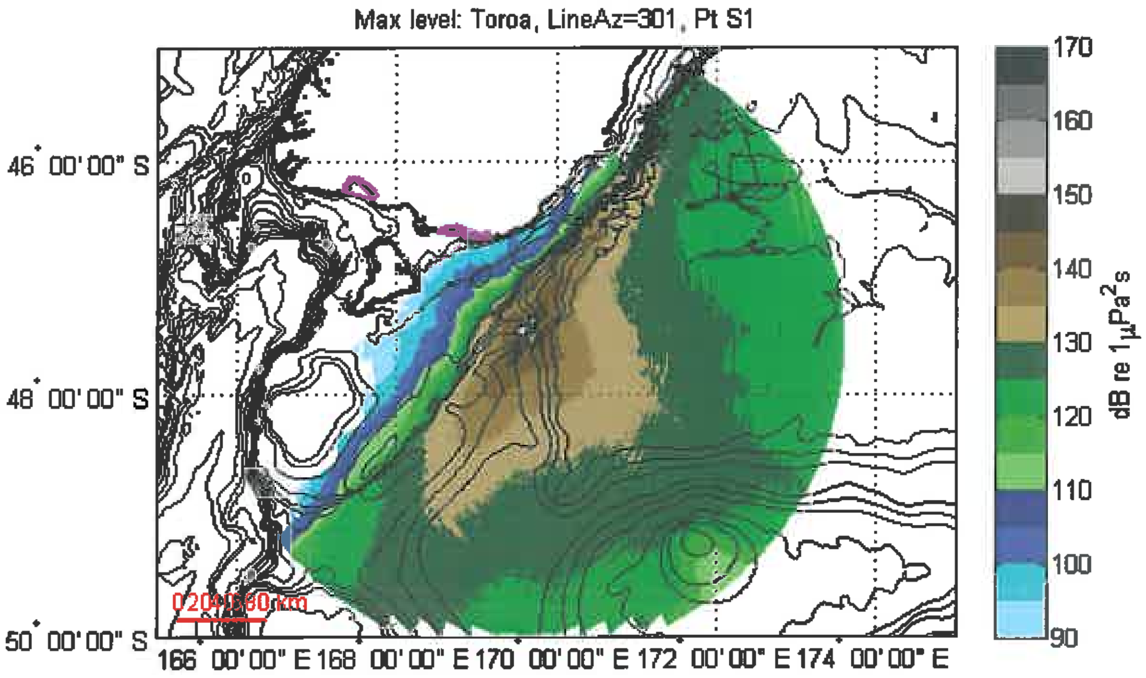



Figure 13. Geographical distribution of modelled sound exposure level for a source at S1 to a maximum range of 300km - autumn sound speed profile. (Maximum level at any depth.) Survey line azimuth is 301°T. The boundary of the Catlins Coast Marine Mammal Sanctuary is plotted in magenta.

Most of the energy is propagated in the cross-line direction, and downslope in the in-line direction, due to a combination of the directionality of the array, which produces maxima in the cross-line direction, and also due to the effects of bathymetry and seafloor composition. The effect of variable bathymetry causes rapid attenuation upslope from the source, and also the change from a silt-clay layered bottom to a carbonate sediment halfspace with high attenuation. The propagation is enhanced downslope, in the inline direction to deeper waters, as this is also one of the main directions of energy propagation with this array.

These effects are illustrated in Figure 14 and Figure 15, which show vertical cross-sections through the sound field produced by the source at S1 in the in-line and cross-line directions respectively. The highest levels are transmitted vertically downward into the seabed; however acoustic energy is also trapped in the ocean interior with some refraction, and also in the South-West direction.

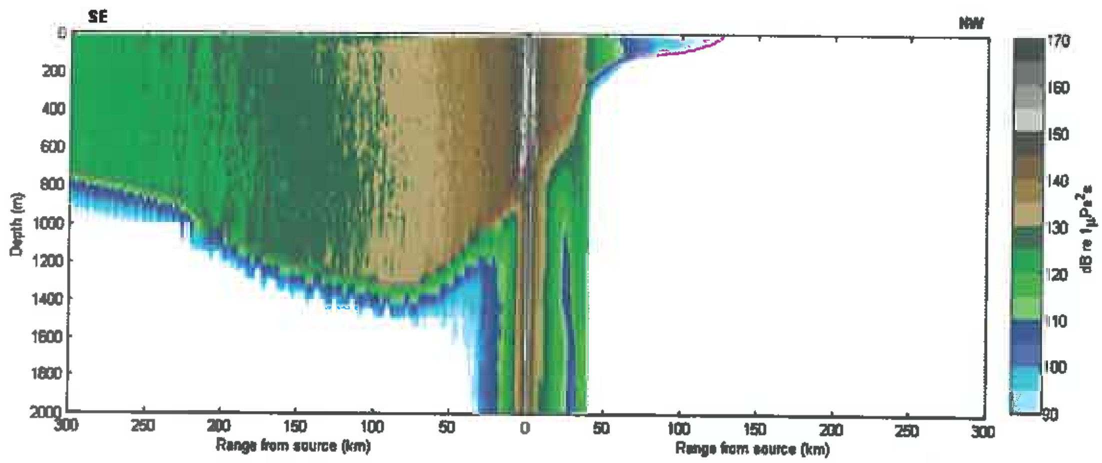



Figure 14. Vertical cross-section through the sound field in the in-line direction (120°T - 300°T), centred on S1, the magenta line outlines seabed.

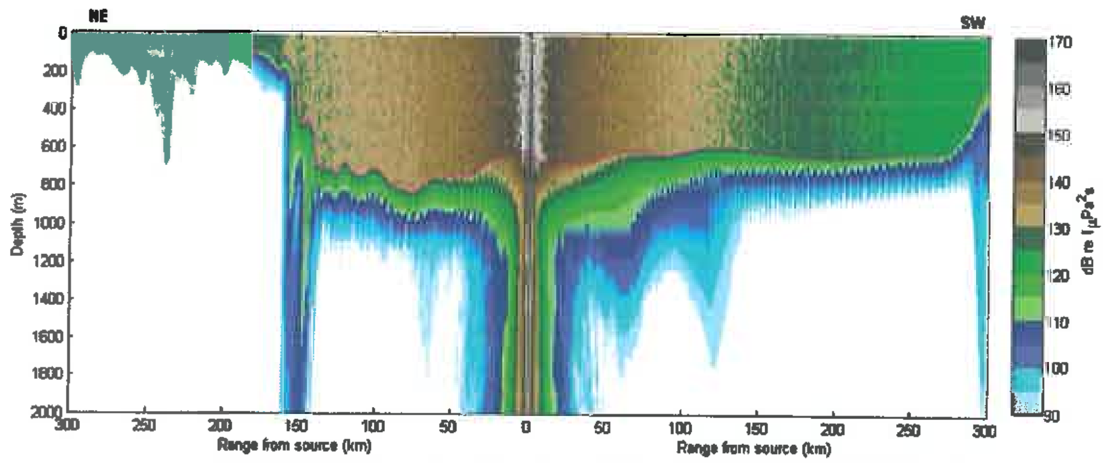



Figure 15. Vertical cross-section through the sound field in the cross-line direction (30°T - 210°T), centred on S1, the magenta line outlines seabed.

# 4 Conclusions

The modelling method used to produce the short range results is very computationally intensive but accurately deals with both the horizontal and vertical directionality of the seismic source and with variations in water depth. The majority of the sound energy is transmitted downward and is absorbed by the seabed, but some energy is trapped and propagates within the ocean interior, and in the cross-line direction to the Campbell Plateau.

The short range modelling predicted that the maximum sound exposure levels from the 3460 cubic-inch Bolt Array would be below the threshold of 186 dB re 1 $\mu Pa^2$.s at 200 m and below 171 dB re 1 $\mu Pa^2$.s at 1 and 1.5 km.

The long range modelling results were highly directional due to the combined effects of seismic source directionality, bathymetry, and seabed model. Levels showed high attenuation inshore of the source and low attenuation offshore. Maximum levels at the outer boundary of the Catlins Coast Marine Mammal Sanctuary due to a source in 630m water depth, in the northern corner of the operational area, were predicted to be lower than 90 dB re 1 $\mu Pa^2$.s.

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# APPENDIX 6

## Toroa 3D MSS Environmental Risk Assessment Summary

| Planned Activities | Consequence | Likelihood | Consequence x Likelihood | Risk Ranking |
|---|---|---|---|---|
| Interference with the fishing community and marine traffic | 3 | 3 | 9 | Medium |
| Interference with marine archaeology, cultural heritage or submarine infrastructure. | 4 | 4 | 16 | Low |
| Changes in seabird behaviour. | 4 | 4 | 16 | Low |
| Introduction of marine pests or invasive species | 3 | 4 | 12 | Low |
| Interaction with marine mammals | 3 | 4 | 12 | Low |
| Changes in abundance or behaviour of fish | 3 | 3 | 9 | Medium |
| Avoidance and startle responses in marine mammals and other marine megafauna | 3 | 3 | 9 | Medium |
| Disruption to feeding activities | 3 | 3 | 9 | Medium |
| Disruption of reproductive behaviour in marine mammals | 3 | 3 | 9 | Medium |
| Interference with acoustic communication signals. | 3 | 3 | 9 | Medium |
| Physiological effects on marine mammals | 3 | 3 | 9 | Medium |
| Physiological effects on seabirds | 4 | 4 | 16 | Low |
| Physiological effects on fish | 3 | 4 | 12 | Low |
| Physiological effects on larvae | 3 | 4 | 12 | Low |
| Physiological effects on benthos | 3 | 4 | 12 | Low |
| Physiological effects on deepwater corals | 4 | 4 | 16 | Low |
| Physiological effects on cephalopods | 3 | 4 | 12 | Low |
| Generation of sewage and greywater | 4 | 3 | 12 | Low |
| Generation of galley waste and garbage | 4 | 3 | 12 | Low |
| Generation of oily waters | 4 | 4 | 16 | Low |
| Atmospheric emissions | 4 | 4 | 16 | Low |
| Cumulative effects from seismic surveys | 4 | 4 | 16 | Low |
| **Unplanned Activities** | | | | |
| Streamer break or loss | 4 | 4 | 16 | Low |
| Fuel or oil spills | 4 | 4 | 16 | Low |
| Vessel collision or sinking | 4 | 3 | 12 | Low |
| **Average Values** | 3.5 | 3.6 | 13 | |
| **Overall Significance Risk Ranking of Toroa 3D MSS Programme** | | | 13 | Low |