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TGS-NOPEC Geophysical Company
Northwest Frontier Multiclient 2D Marine Seismic Survey
Marine Mammal Impact Assessment
14 November 2014

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List of Acronyms

ACE Annual Catch Entitlement

AEI Areas of Ecological Importance
ALARP As Low as Reasonably Practicable

AOI Area of Interest

BPA Benthic Protected Area
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

DC D'Urville Current

DOC Department of Conservation

ECC East Cape Currents

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

FMA Fisheries Management Area

HSE Health and Safety in Employment

IAPPC International Air Pollution Prevention Certificate
IOPPC International Oil Pollution Prevention Certificate

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

MEC Marine Environment Classification

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 Limited

MSS Marine Seismic Survey



TGS 2D - Northwest Frontier - Multiclient - MMIA -Final.docx

NABIS National Aquatic Biodiversity Information System

NIWA National Institute of Water and Atmospheric Research

Nm Nautical Mile
NZ New Zealand

NZP&M New Zealand Petroleum & Minerals

PAM Passive Acoustic Monitoring
PEP Petroleum Exploration Permit

PEPANZ Petroleum Exploration & Production Association New Zealand

PNA Protected Natural Area

QMS Quota Management System

RMA Resource Management Act 1991

SC Southland Current

SEL Sound Exposure Level

SOPEP Shipboard Oil Pollution Emergency Plan

SRD Self-Recovery Devices

STLM Sound Transmission Loss Modelling
TACC Total Allowable Commercial Catch

TGS TGS-NOPEC Geophysical Company Pty Ltd

WAUC West Auckland Current

WC Westland Current

WCNI West Coast North Island



1 Introduction

1.1 Background

TGS-NOPEC Geophysical Company (TGS), a leading geophysical services company, are proposing to acquire a 2D Marine Seismic Survey (MSS) of approximately 17,000 lineal km in the Reinga, New Caledonia and Taranaki Basins. The Survey Area will be located within the 136,512 km² Petroleum Prospecting Permit (PPP) 56377 and will be bound by an Operational Area; allowing for operation of line turns, acoustic source testing and soft start initiation (Figure 1). It is anticipated that TGS's Northwest Frontier (NWF) 2D MSS will take approximately 4-5 months to acquire, depending on weather constraints and marine mammal encounters. The seismic vessel *Aquila Explorer* has been contracted to undertake the NWF 2D MSS with an anticipated commencement date of 1 December 2014.

Under Section 23 of the Crown Minerals Act 1991, a PPP authorises the permit holder to prospect for petroleum deposits or occurrences. TGS have been granted PPP 56377 as a speculative prospector under Section 90(7) of the Crown Mineral Act on a non-exclusive basis for a period of six months, allowing TGS to undertake geological or geophysical surveying within PPP 56377. Further details in regards to the Crown Minerals Act is provided in Section 2.1.

TGS will undertake the NWF 2D MSS as a multi-client MSS and have secured a contract with Statoil New Zealand to acquire a 2D MSS within the 9,800 km² Petroleum Exploration Permit (PEP) 55781. Statoil have a work commitment to acquire and process a minimum of 3,500 kms of 2D seismic data within PEP 55781.

The NWF MSS will acquire data to provide a general understanding of the regional geological structure within PPP 56377 and to identify more prospective areas for further investigations. Further details on the difference between a 2D and 3D MSS are provided in Section 3.1.

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) (Department of Conservation (DOC), 2013). The Code of Conduct is further explained in Section 2.3.

Environmental Offshore Services Ltd has been contracted to prepare the NWF 2D 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 NWF 2D MSS, the sensitive environments and marine species in the surrounding areas and mitigation measures to avoid or minimise any potential effects to as low as reasonably practicable (ALARP).



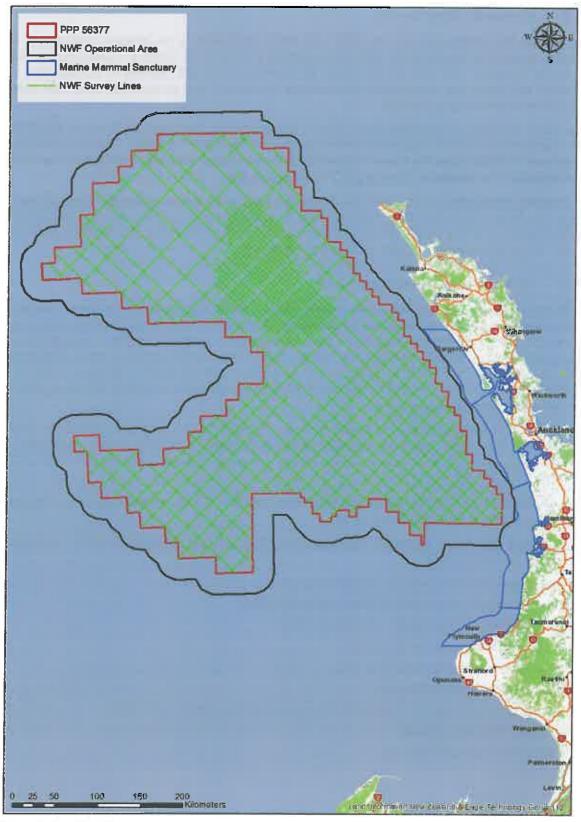


Figure 1: Location Map of PPP 56377, NWF Operational Area, Marine Mammal Sanctuary and Proposed Survey Lines



1.2 General Approach

As part of the preparation for the NWF 2D MSS, the MMIA is an integral component to receive regulatory approval for TGS to undertake the NWF 2D MSS in adherence to the Code of Conduct. As well as the Code of Conduct, TGS will operate in accordance to relevant NZ laws and regulations, international guidelines and procedures and their own internal environmental standards.

The NWF 2D MSS is classified as a 'Level 1 Survey' within the Code of Conduct and TGS will comply with these requirements while carrying out the NWF 2D MSS. The requirements of a Level 1 MSS within the Code of Conduct and associated mitigation measures that TGS will implement is outlined in <u>Section 2.3.1</u> and <u>Section 5.3.1</u>.

During the preparation of the NWF 2D MMIA an extensive review of literature and existing data has been undertaken from both national and international sources and is summarised within Section 4 of this MMIA for the existing environments surrounding the NWF Operational Area. A full list of references can be found in Section 8.

1.3 Stakeholder Engagement

TGS has engaged with key interested parties, stakeholders, hapu and iwi that were identified in relation to the MSS activities within the NWF Operational Area and extended from New Plymouth to the Northland Region. This engagement process involved groups being engaged either in person, through the sending of an information sheet or being contacted over the phone or via email to describe the proposed TGS 2D MSS operations within the NWF Operational Area. A copy of the information sheet sent out as part of the engagement process is attached in <u>Appendix 1</u>.

Any engagements undertaken by Statoil in relation to PEP 55781, which lies within the NWF Operational Area have not been included within this MMIA. The stakeholder engagement register in Appendix 2 has focused solely on the proposed acquisition of the NWF 2D MSS by TGS.

The Waikato-Tainui Environmental Management Plan (2013) was considered for the section regarding engagement with Tainui hapu.

The groups that were engaged with (or those that did not respond despite numerous attempts) are listed below:

- Department of Conservation National Office;
- Department of Conservation New Plymouth Office;
- Department of Conservation Hamilton Office;
- Environmental Protection Authority;
- New Zealand Petroleum & Minerals;
- Ministry for Primary Industries;
- Petroleum Exploration & Production Associated New Zealand (PEPANZ);
- · Taranaki Regional Council;
- Te Runanga o Ngati Mutunga;
- Ngati Tama;
- Port Taranaki;
- Ngati Mahuta;
- Tainui Kawhia Incorporation Ngati Hikairo;
- · Waahi Whanui Trust;
- Nga Hapu o Ngaruahine lwi inc;



- Taranaki lwi Trust:
- Te Atiawa Iwi Authority;
- · Deepwater Group;
- · Sealord;
- · Egmont Seafoods:
- Talley's Group;
- · Sanford Limited;
- Southern Inshore Fisheries Management Company Limited;
- · NZ Federation of Commercial Fishermen;
- Port of Auckland:
- Port of Tauranga;
- Land Information New Zealand;
- Fishing Vessel Management Services;
- Fisheries Inshore NZ:
- Te Runanga Nui o Te Aupouri;
- Nga Hapu o Ahipara;
- Te Oneroa a Tohe;
- Ngati Kuri Trust Board;
- · Kaitaia locals;
- Ngati Wai Trust;
- Te Uri o Hau Settlement Trust:
- Te Runanga o Ngati Whatua;
- · Te Roroa Whatu Ora Trust;
- · Maniapoto Maori Trust Board;
- · Hauauru ki Uta Regional Management Committee;
- Mokau Regional Management Committee;
- Ngati Te Ata Claims Support Whanau Trust;
- Ngati Paoa Trust Board;
- · Ngati Tamaoho Trust;
- Te Kawerau lwi Tribal Authority:
- Ngati Kahu ki Whangaroa Trust Board;
- · Ngati Kuri Trust Board;
- Te Runanga Nui o Te Aupouri Trust;
- Te Runanga o Te Rarawa;
- Te Runananga-a-iwi o Ngati Kahu;
- Ngati Rehua-Ngatiwa Ki Aotea Trust;
- Ngati Mahuta;
- The Proprietors of Taharoa C Block;
- · Waahi Whaanui Trust;
- Waikato Tainui Te Kauhanganui Incorporated;
- Ngati Whatua o Orakei Whai Rawa Limited;
- Independent Maori Statutory Board;



- Waahi Whaanui Trust:
- Nga Maunga Whakahii o Kaipara Development Trust;
- · Ngati Manuhiri Settlement Trust;
- · University of Auckland;
- Venture Taranaki;
- Waikato Regional Council;
- Auckland Council:
- Northland Regional Council;
- New Plymouth Sportfishing & Underwater Club;
- · Raglan Sportfishing Club;
- · Waikato Sportfishing Club; and
- Kawhia Angling & Boating Club.

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

1.4 Research

Throughout the world where MSSs are undertaken, research is being undertaken to assess any potential effects from MSS operations on marine species and habitats. Within the Code of Conduct it is identified that research should be undertaken which is relevant to the local species, habitats and conditions (Department of Conservation (DOC), 2013), while not duplicating international efforts.

Under the Code of Conduct, within 60 days following the completion of the NWF 2D 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. There is presently very little information regarding what marine mammals live in the NWF Operational Area, so having dedicated trained and experienced MMOs on the *Aquila Explorer* will increase DOC's knowledge on marine mammals for this area.

While conducting the NWF 2D MSS; TGS will have Massey University perform a necropsy on any marine mammals that may be found dead and cannot be attributed to shark attacks or vessel collisions, inshore of the NWF Operational Area, from Cape Reinga to New Plymouth during the NWF 2D MSS and for a period two weeks after the NWF 2D MSS is completed. If a necropsy is performed it will be to assess whether the cause of death was from any auditory pressure related injuries. DOC will be responsible for all aspects of undertaking the necropsy and coordination with pathologists at Massey University; however TGS will cover the associated costs.

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 has the role of maximising 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 NWF 2D MSS, TGS 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, 2014).

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.

TGS have applied for a 136,512 km² PPP, which under Section 23 of the Crown Minerals Act, allows for conducting reconnaissance and general investigations of an area, generally through acquisition of geological and geophysical data for the purpose of providing information for further petroleum exploration. The duration of a PPP can be for up to four years or an earlier specified date; however, TGS have only applied for a PPP duration of six months. A PPP may not be extended beyond four years after the permit's commencement date, and there are no subsequent rights to the permit holder to obtain petroleum exploration or petroleum mining permits over all or part of the area of a PPP. PPP's are normally granted on a non-exclusive basis, however there may be exceptions where exclusive rights to applicants are granted but there are a number of requirements that have to be implemented for this to occur, and exclusive PPP's will generally have a maximum duration of two years.

Under the Crown Minerals Act, the type of information protection and confidentiality provisions applied to the data which is acquired under a PPP, and subsequently provided to NZP&M, depend on whether or not the PPP holder is a 'speculative prospector'. Section 90C of the Crown Minerals Act allows for a non-exclusive PPP holder who carries out activities under the PPP solely for the purpose of on-selling the information obtained on a non-exclusive basis to petroleum explorers and producers to be classed as a speculative prospector. TGS are considered as a speculative prospector.

Any information that a speculative prospector has provided to NZP&M will not be released to the public by NZP&M until 15 years after it has been obtained by the PPP holder. As a result, speculative prospectors now know that they have the exclusive rights to seismic data they acquire in NZ for 15 years. This allows them to work with operators and the Crown to get subsequent blocks released over potential petroleum resources for further exploration activities.

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;
- · 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 approve a MMIA 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

There is the potential for MSS operations to have an adverse effect on marine mammals and this was the underlying principle for the development of the Code of Conduct and the associated mitigation zones from the acoustic source. Within the Code of Conduct – Schedule 2, it classifies all the cetaceans listed as Species of Concern and includes all NZ cetacean species except common dolphins, dusky dolphins and NZ fur seals (Department of Conservation (DOC), 2013).



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.

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 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 became required to comply with the Code of Conduct. This resulted in a review of the 2012 Code of Conduct 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 included 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 <u>Section 2.3.1</u>.

2.3.1 General requirements

2.3.1.1 Notification

Any operator undertaking a MSS (except those classified as Level 3 (see <u>Section 2.3.2</u>)) 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 4 July 2014 in regards to the NWF 2D MSS within PPP 56377.

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 MSS acquisition to ensure that all potential environmental effects and sensitivities have been identified and measures to reduce those 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 requirements 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, technical experts have helped refine the AEI maps where data was absent or incomplete.

Within the Code of Conduct it states that under normal circumstances a MSS will not be planned in any sensitive ecologically important areas or during key biological periods where Species of Concern are likely to be calving, resting, feeding or migrating, or where risks are particularly evident such as in confined waters. The NWF 2D Operational Area is located within an AEI (Figure 34).

TGS lodged a work commitment to the NZ Government as part of their PPP application that they can undertake a 2D MSS that will meet the requirements stipulated within the petroleum regulations and more specifically PPP 56377; this provides TGS with non-exclusive rights of



the PPP for a duration of six months. The timing of the NWF 2D MSS is scheduled to commence at the start of December 2014 and coincide with the settled weather period from December to March/April. This time of year will help enable the NWF 2D MSS to be undertaken in the shortest possible timeframe; reducing excess noise emitted to the marine environment for a longer period due to weather delays. It is also noted that information gathered from the MMO reports following the completion of the NWF 2D MSS will provide marine mammal sighting information along the west coast of NZ, in which there have been very few recorded marine mammal sightings on the DOC database (Figure 2).

When MSS are conducted in an AEI as detailed in Schedule 1 of the Code of Conduct, and it is necessary and unavoidable; additional mitigation measures are to be put in place. As the NWF 2D Operational Area is located within an AEI the additional measures that TGS will implement are identified in Section 5.3.2.

When an MSS is undertaken within an AEI, the Code of Conduct 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 *Aquila Explorer* and the environmental conditions (i.e. bathymetry, substrate, water temperature and underlying geology) within the NWF 2D Operational Area. The Code of Conduct states that if Sound Exposure Levels (SEL's) are predicted to exceed 171 dB re 1μ Pa².s (behaviour criteria) corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1μ Pa².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 <u>Section 5.1.2.1</u> however, it should be noted that based on the STLM results, the inshore boundary of the survey area has been revised to eliminate the shallowest areas from the NWF 2D MSS. The STLM demonstrated that the shallowest southeast corner of TGS's original Operational Area had the highest SEL's, which decrease as water depth increases (<u>Section 5.1.2.1</u>). As a result, TGS refined the Survey Area and opted to stay beyond the 300 m depth contour except for well ties into Tarapunga-1 and Korimako-1 wells.



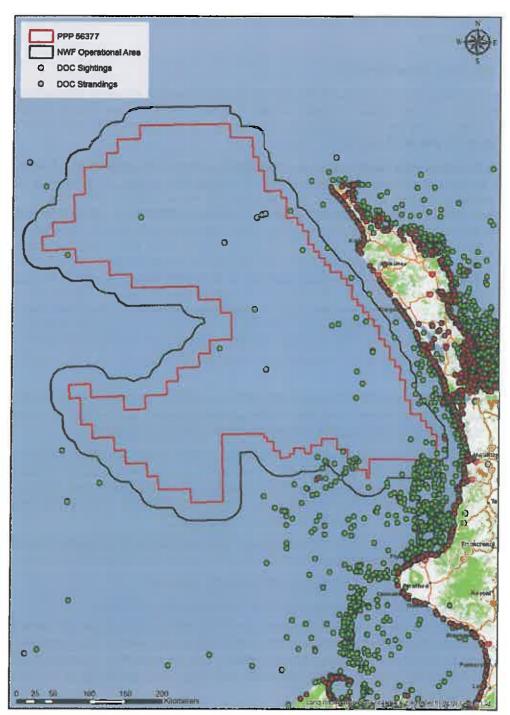


Figure 2: Recorded Cetacean Sighting and Strandings (1960 – 2014) (Source: DOC marine mammals sightings database).

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 NWF 2D 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 (in³)). 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 TGS 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. Blue Planet Marine is the provider of MMOs and the PAM system for this survey. A Vanishing Point (VP) PAM system will be utilised for the NWF 2D 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. To achieve a workable balance between signals and noise (i.e., the signal to noise ratio or SNR) the VP system utilises two independent hydrophone chains. Analogue filtering is utilised to customise SNR. The low frequency elements are AQ4s. The manufacturers state a near flat +/- 1.5dB sensitivity from 1Hz to 10 kHz. The high frequency chains have better omni-directional high frequency sensitivity overlapping with the low frequency elements and are sensitive up to 250 kHz. The VP system is able to sample up to 500 kHz which is well in excess of the required 360 kHz within the Code of Conduct. Therefore the VP system used by Blue Planet Marine has arrays incorporating appropriate hydrophone elements (1 Hz to in excess of 180 kHz range) and data acquisition card technology for sampling relevant frequencies (to greater than 360 kHz) used by NZ cetacean species. It has also been confirmed that the VP PAM system has the capability to determine distance and bearing to 1.5km and has full system redundancy.

The DOC-endorsed senior PAM Operator that will be onboard the *Aquila Explorer* during the NWF 2D MSS also confirmed that the PAM system planned to be used is suitable for detection of NZ endemic and vagrant marine mammal species (Appendix 3).

Technical details of the PAM system to be used in the NWF 2D 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 Blue Planet Marine and is attached in Appendix 4.

To undertake the NWF 2D 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 NWF 2D MSS is strictly for the detection and data collection of marine mammal sightings, and instructing crew on the Code of Conduct requirements and the crew requirements when a marine mammal is detected within the relevant mitigation zone (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 NWF 2D MSS the MMOs onboard the *Aquila Explorer* 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 be made from discussions between DOC and TGS, 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 *Aquila Explorer* 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 last shotpoint of the NWF 2D 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 NWF 2D MSS acoustic source can only be activated if it is within the NWF Operational Area (<u>Figure 1</u>) and no marine mammals have been observed or detected in the relevant mitigation zones (<u>Section 2.3.2.4</u>) and has followed the procedures listed below in this section.

During daylight hours the NWF 2D 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 NWF 2D 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 (4400 in³) 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 *Aquila Explorer* arrives at the NWF 2D 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 NZ 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 *Aquila Explorer* returns to the NWF Operational Area after a crew change or 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 ((Department of Conservation (DOC), 2013) – 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 NWF 2D 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.

2.4 Marine Mammal Sanctuaries

There are six gazetted Marine Mammal Sanctuaries (MMS) around NZ that were implemented to protect marine mammals from harmful human impacts, particularly in vulnerable areas such as breeding grounds or migratory routes. However, the most important aspect of a MMS is the presence of the general habitat of an endangered species, such as Hector's and Maui's dolphins. 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. A MMS does not exclude all fishing or seabed mining activities; however a MMS places restrictions on seismic surveys to prevent and minimise disturbance of marine mammals the MMS were gazetted to protect.

There is a MMS is in place for a large area of the West Coast North Island (WCNI) of NZ, covering a large proportion of the endemic Maui's dolphins range. The boundary of the WCNI MMS spans an area of coastline from Oakura Beach in the south to Maunganui Bluff in Northland and extends offshore to 12 Nm. The total area of this sanctuary is approximately 1,200,086 ha and covers 2,164 km of coastline. Within certain parts of this sanctuary there are restrictions on acoustic seismic surveys, seabed mining activities, set net and trawl fishing. Seismic surveys are regulated within the entire MMS in accordance with the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008. Seabed mining is restricted, while set net and trawl fishing is restricted under the Fisheries Act. The West Coast North Island MMS was gazetted to protect Maui's and Hector's dolphins.

In 2013, the Minister of Conservation varied the WCNI MMS to prohibit commercial and recreational set net fishing between 2 – 7 Nm offshore between Pariokariwa Point and the Waiwhakaiho River, Taranaki under the Marine Mammals Protection Act 1978. This area covers 350 km² of the MMS. The purpose of the variation to the MMS was to provide greater protection to Maui's dolphins from the risks resulting from set net fishing (commercial and recreational).



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. The acoustic wave travels through the earth and portions of the wave are reflected by the underlying rock layers, this 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 (<u>Figure 3</u>). In contrast, a 3D MSS is a more complex method which involves a greater investment and 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.

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

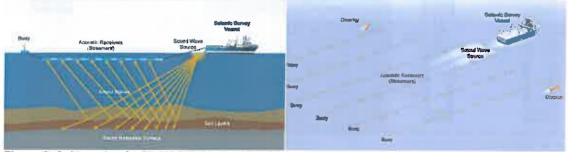


Figure 3: Schematic of a 2D MSS (left) and 3D MSS (right)

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 (<u>Figure 4</u>). 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 (<u>Figure 4</u>) 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, where 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 $\sim 220-250$ 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.

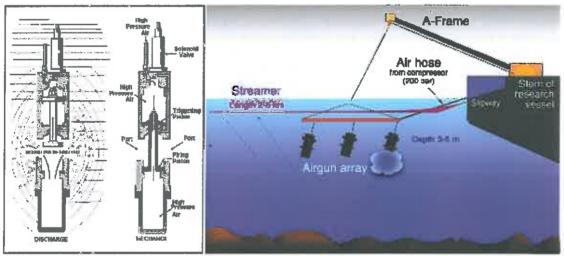


Figure 4: Schematic cross section of a typical acoustic source and a sub-surface multi acoustic source array

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 μ ' – the amplitude of a sound wave's loudness with a pressure of 1 microPascal (μ Pa). Whereas the reference level for sound in air is dB re 20 μ Pa. 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 equal to the same sound level in the air.

Sound Exposure Levels are the total noise energy produced from a single noise event. It is a logarithmic measure of the sound pressure level squared and integrated over a stated period of time or event, relative to a reference sound pressure value. SEL's are measured in dB and normalised to a one second period.

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	<u> </u>	100 dB
Blue whale	£	190 dB
Live rock music	110 dB	172 dB
Thunderclap or chainsaw	120 dB	182 dB
Large ship	¥8	200 dB
Earthquake	1.5	210 dB
Seismic array at 1 metre	158-178 dB	220-240 dB
Bottlenose dolphin	859	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 streamer

For a 2D MSS one streamer is towed behind the seismic vessel, whereas for a 3D MSS multiple streamers can be towed. 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 streamer detects the very low level of reflection 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. The hydrophones within the streamer sections are responsive across a bandwidth of $0-200\,\mathrm{hz}$.

Each streamer is divided into sections (50-100 m in length) to allow for modular replacement of damaged components. A solid streamer will mostly be used for the NWF 2D MSS which is constructed from neutrally buoyant extruded foam and has a number of advantages over fluid filled streamers: it is 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 streamer, resulting in less infill lines (for 3D surveys), reducing the cumulative sound energy introduced into the marine environment. The exception to this is a number of sections are likely to be gel-filled, as opposed to solid.

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 streamer a tail buoy is connected to provide both a hazard warning (lights and radar reflector) of the submerged towed streamer between the tail buoy and vessel, and to act as a platform for positional systems of the streamer (<u>Figure 5</u>). During the NWF 2D MSS, the *Aquila Explorer* will be travelling at approximately 4.5 kts so the streamer tail buoy will be travelling approximately 70 minutes behind the vessel.

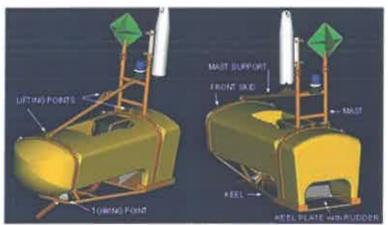


Figure 5: Example of a tail buoy with light and radar reflector

3.2 Northwest Frontier 2D Marine Seismic Survey

The NWF 2D MSS will use the seismic vessel *Aquila Explorer* and will tow one streamer, 10 km in length. The acoustic source will have an effective volume of 4,400 in³ and will be comprised of four subarrays with 10 acoustic sources on all but one of the subarrays, which has nine. The acoustic array will be located at a depth of 8 m (+/- 1 m) below the sea surface and approximately 121 m behind the survey vessel. The depth of the subarrays will ensure 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 NWF 2D MSS outlined within this MMIA. The STLM is further discussed in <u>Section 5.1.2.1</u> and is attached in <u>Appendix 5</u>.



The acoustic source will have an operating pressure of 2,000 psi and fired at a sourcepoint interval of 25 m apart, where for a typical boat speed of 4.5 knots (kts), relates to a sourcepoint activation every 11 seconds.

The NWF 2D Survey Area is located within PPP 56377, although the NWF Operational Area does extend beyond this permit area (<u>Figure 1</u>). TGS are planning to acquire the NWF 2D MSS in early December 2014 and is scheduled to take approximately 4-5 months. 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 *Aquila Explorer* are provided in <u>Table 2</u>. One support vessel (*Ocean Pioneer*, <u>Figure 7</u>) will be contracted for the duration of the NWF 2D MSS and will be in close proximity to the *Aquila Explorer* at all times except if the support vessel has to go into port for supplies.

There are four main components involved with the acquisition of the NWF 2D MSS:

- Mobilisation of Aquila Explorer to NWF Operational Area: After the Aquila Explorer
 has been cleared through customs and received supplies in Port Taranaki, it will mobilise
 to the NWF Operational Area. The Ocean Pioneer will accompany the Aquila Explorer at
 all times during the passage to the NWF Operational Area. During transit to the NWF
 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 *Aquila Explorer* will utilise the wind and currents present at the time for the successful deployment of the streamer and acoustic source and will take approximately 18 hours to deploy. Once all the seismic gear is deployed the MMO's 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 NWF 2D MSS;
- Data Acquisition: The Aquila Explorer 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 Aquila Explorer will monitor for marine mammals throughout the 24 hour period for the duration of the NWF 2D MSS to ensure compliance with a Level 1 survey under the Code of Conduct;
- Crew change and Refuelling: For the duration of the NWF 2D MSS, every five weeks
 the Aquila Explorer will return to Port Taranaki for a crew change, refuelling and to take on
 fresh supplies. During this period once the Aquila Explorer leaves the NWF 2D Survey
 Area, no seismic acquisition will occur; and
- Demobilisation: Once the Aquila Explorer has completed the NWF 2D MSS the seismic array will be retrieved and the vessel will return to Port Taranaki or wherever its next destination 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 streamer may be left deployed.





Figure 6: Seismic Survey Vessel - Aquila Explorer



Figure 7: Seismic Support Vessel - Ocean Ploneer



Table 2: Aquila Explorer Technical Specifications

Seismic Survey Vessel – Ge	neral Specifications					
Vessel Name	Aquila Explorer					
Vessel Owner	Aquila Explorer Inc.					
Engine Details	2 x MAK 6M AK 1770 KW					
Fuel Capacity	1,254 m ³					
Seismic Survey Vessel – Dimensions and capacities						
Vessel Length	71 m					
Vessel Beam	17.5 m					
Max Draft	5.45 m					
Gross Tonnage	3,057 t					
Cruising Speed	11 knots					

Table 3: NWF 2D Seismic Specifications

Parameter	Specifications
Total array volume	4,400 in ³
Acoustic Source	Bolt 1900 LLXT
Number of sub-arrays	4
Number of acoustic sources per sub-array	10
Array length	14 m
Array width	30 m
Nominal operating pressure	2,000 psi
Source Frequency	2 - 250 Hz
Acoustic source tow depth	8 m (+/- 1m)
Distance from the stern	121 m
Number of streamers	1
Streamer length	10 km
Streamer manufacturer/model	Sercel Seal
Towing depth	Between 8 m and 30 m

3.3 Navigational Safety

During the NWF 2D MSS, the *Aquila Explorer* will be towing one streamer of 10 km in length and in doing so will be 'restricted in its ability to manoeuvre'. At the operational speed while acquiring seismic data of ~4.5 kts the vessel cannot turn quickly so 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. Seabird Exploration (who own the *Aquila Explorer*) will issue a Notice to Mariners and a coastal navigation warning will be broadcast daily on maritime radio advising of the NWF Operational Area and the presence of the *Aquila Explorer* and her restriction in ability to manoeuvre while towing the MSS array. The *Aquila Explorer* 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 potential users of that area of ocean, while the presence of the support vessel will be utilised to notify any boats that are unaware of the seismic operations or those vessels that cannot be reached via VHF radio. In accordance with International Maritime Law the *Aquila Explorer* 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. A tail buoy will mark the end of the streamer and has 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 NWF 2D MSS has the requirement to not only gather the best information from the underlying geology and hydrocarbon potential within the NWF Survey Area but to also reduce any adverse effects on the marine environment to the fullest extent practicable.

TGS will use a 'Bolt acoustic source' for the NWF 2D MSS, with the acoustic source consisting of four 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 TGS 2D MSS design, TGS performed modelling to identify the source size necessary to adequately record data from a pre-determined depth. A source volume of 4400 in³ was identified as an optimum volume given the water depths and geology for the survey to achieve its objectives. The larger source volumes available onboard the *Aquila Explorer* (i.e. 6,620 in³ and 6,900 in³) were therefore not selected in the interest of minimising unnecessary noise being released into the marine environment.

The acquisition period for the NWF 2D 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 through the Cook Strait and up to the South Pacific feeding grounds. The DOC Cook Strait monitoring project is undertaken in June-July to coincide with the peak of the migration.

TGS have a work programme commitment for PPP 56377 that has been agreed with NZP&M to provide a general understanding of the regional geological structure and to identify more prospective areas which can be more comprehensively examined and potential areas that can be released as part of the block offer process; of which 2D seismic data acquisition is required. As a result there is no 'do nothing' option in regards to a 2D seismic survey.



4 Environmental Description

4.1 Physical Environment

4.1.1 Meteorology

Anticyclones are a major feature of the weather in the Australian-NZ region. These circulation systems migrate eastwards every six to seven days across NZ with their centres generally passing across the North Island. Overall, anticyclones will follow northerly paths in the spring and southerly paths in the autumn and winter.

Troughs of low pressure are found between the anticyclones with associated cold fronts, orientated northwest to southeast. As these cold fronts arrive from the west, northwesterly winds become stronger and cloud levels increase. This is generally followed by a period of rain which can last up to several hours as the front passes over. After the front has gone through, there is a change to cold showery southwest winds.

The area of coastline adjacent to the NWF 2D MSS survey area spans three broad climate zones as described by NIWA: northern NZ, central North Island and southwest North Island (NIWA, 2014).

The sub-tropical northern zone has warm humid summers and mild winters. Typical summer daytime maximum air temperatures range from 22°C to 26°C, but seldom exceed 30°C. Winter daytime maximum air temperatures range from 12°C to 17°C.

The central North Island zone is more sheltered and is one of the less windy areas of NZ. Typical summer daytime maximum air temperatures range from 21°C to 26°C, rarely exceeding 30°C. Winters are cool and this is normally the most unsettled time of the year.

The most southerly section of the coastline adjacent to the survey area falls within the southwest North Island zone. The area is more exposed to the Tasman Sea weather fronts and therefore windier. The most settled weather occurs during summer and early autumn. Summers are warm with typical daytime maximum air temperatures ranging from 19°C to 24°C, seldom exceeding 30°C. Winters are relatively mild and fairly unsettled in the northern part of this zone with typical winter daytime maximum air temperatures from 10°C to 14°C.

Weather conditions from New Plymouth and Kaitaia have been used as indicative for the NWF Operational Area, with mean monthly weather parameters at New Plymouth shown in <u>Table 4</u> and Kaitaia in <u>Table 5</u>.

Table 4: Mean Monthly weather parameters at New Plymouth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	54	83	68	104	112	123	110	101	105	117	102	106
Temp – avg. daytime (°C)	21	22	20	18	16	14	13	13	14	16	17	19
Temp – avg. night time (°C)	14	14	13	11	10	8	7	7	8	10	10	13
Avg. wind speed (kts)	9	9	9	9	10	10	10	10	11	12	11	10
Max. wind speed (kts)	30	38	30	33	35	37	31	31	47	58	31	37

(Weather2, 2014b)



Table 5: Mean Monthly weather parameters at Kaltaia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	85	58	66	72	120	114	123	202	120	99	111	84
Temp – avg. daytime (°C)	24	24	23	21	18	16	15	15	17	18	20	22
Temp – avg. night time (°C)	15	15	14	13	10	9	9	8	10	11	12	13
Avg. wind speed (kts)	8	7	7	7	8	9	9	10	10	10	9	8
Max. wind speed (kts)	32	28	31	28	30	28	32	45	30	34	28	24

(Weather2, 2014a)

MetOcean Services Ltd (MSL) provided a modelling analysis for four geographic distinct locations within PPP 56377 (Figure 8). These four locations were modelled for wind, waves and currents (see <u>Section 4.1.2.1</u> and <u>Section 4.1.2.3</u>).

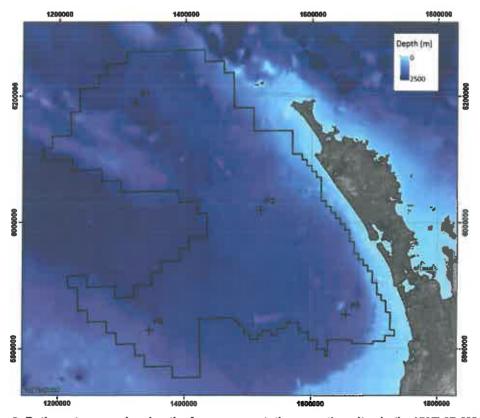


Figure 8: Bathymetry map showing the four representative reporting sites in the NWF 2D MSS survey area

Overall, the four modelled locations are similar in terms of wind speed and direction. P1 shows a very slight predominance of a southwesterly wind direction. Northwesterly, westerly and southwesterly winds are dominant in P2 whereas the southwesterly component is most prominent for P3 and P4 (Figure 9, Figure 10, Figure 11, and Figure 12). For all four sites within PPP 56377, the windiest month is July (Table 6).



Table 6: Average wind speed by month for P1, P2, P3 and P4 within PPP 56377

		Mean w	ind speed	(m/s)
Month	P 1	P 2	P 3	P4
January	6.66	6.57	6.65	6.79
February	6.46	6.49	6.51	6.67
March	6.9	7.03	7.12	7.27
April	7.22	7.19	7.26	7.57
May	7.83	8.03	8.14	8.25
June	8.24	8.47	8.64	8.71
July	8.59	8.73	8.69	8.76
August	8.12	8.33	8.36	8.50
September	7.89	8.18	8.31	8.59
October	7.61	7.90	8.12	8.32
November	7.09	7.36	7.57	7.73
December	6.56	6.71	6.92	7.21

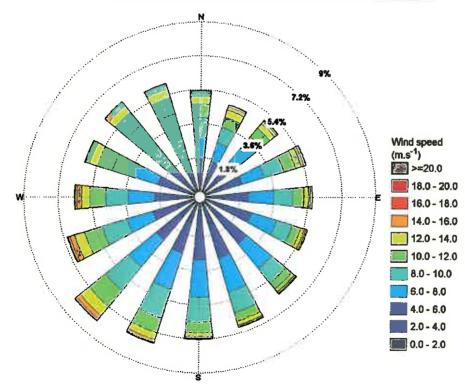


Figure 9: Annual wind rose from P1 – northern end of PPP 56377



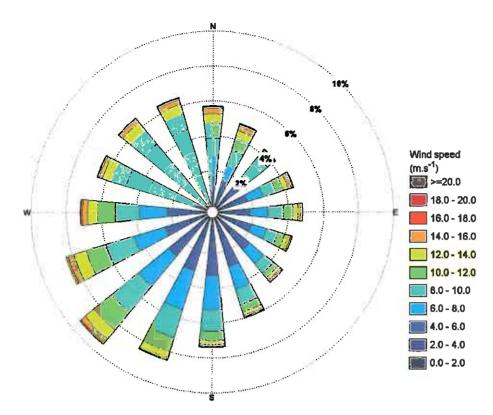


Figure 10: Annual wind rose from P2 - centre of PPP 56377

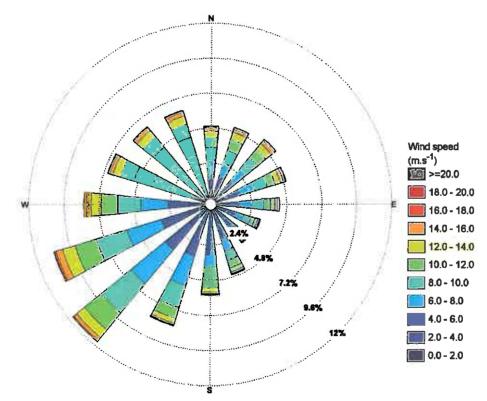


Figure 11: Annual wind rose from Location 3 - southeast end of PPP 56377



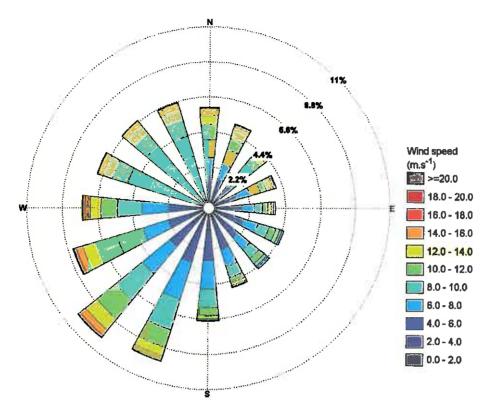


Figure 12: Annual wind rose from Location 4 – southwest of PPP 56377

4.1.2 Oceanography

4.1.2.1 Current Regime

Around the New Zealand 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.

New Zealand lies in the path of eastward-flowing currents, which are driven by winds that blow across the South Pacific Ocean. This results in New Zealand being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the Roaring Forties westerly winds to the south (Gorman *et al.*, 2005). The anti-clockwise circulation of the gyre is initiated by the winds but is then further modified by the spin of the earth (Coriolis Effect).

The eastward flow out of the Tasman Sea splits into two currents across the top of the North Island of New Zealand: the West Auckland Current (WAUC) which flows from Cape Reinga towards Kaipara; and the East Auckland Current (EAC) which flows from the North Cape towards the Bay of Plenty (Brodie, 1960, Heath, 1985, Stanton, 1973).

As the WAUC progresses southward, it is met by the north-flowing Westland Current (WC) (Figure 13) which courses from the west coast of the South Island up to the west coast of the North Island where it weakens and becomes subject to seasonal variability. As a result, the northern limit of the WC (and so the southern limit of the WAUC) is variable, reflecting both local weather conditions and seasonality (Brodie, 1960, Ridgway, 1980, Stanton, 1973).

A recent study by Sutton & Bowen (2011) confirms the existence of a southeastern flow (WAUC), but only in waters exceeding 1,000 m in depth, and a variable current regime in shallower waters (Sutton and Bowen, 2011).



The complex ridge system (i.e. Norfolk Ridge and Lord Howe Rise) which exists off the northwest of the North Island strongly impacts the oceanographic characteristics of the area (see Section 4.1.3.1). As the East Australian Current flows over the ridges and other irregularities in the sea floor (i.e. seamounts and banks), it intensifies which results in the creation of the Tasman Front (Denham and Crook, 1976, Heath, 1980, Stanton and Hill, 1972, Stanton, 1981, Tilburg et al., 2001). This front was initially thought to exist only over the Norfolk Ridge but it was then demonstrated to be a permanent feature which spans 600 km over both the Norfolk Ridge and the Lord Howe Rise between 30° and 35° S and down to depths of 400 m (Denham and Crook, 1976, Stanton, 1981, Tilburg et al., 2001). In fact, the fastest flow of water in northwest New Zealand waters occurs over the Norfolk Ridge (Heath, 1980). In addition, the ridge induces waves in the eastward flow and causes the current to turn north and then south. This results in the current north of the Three Kings Islands displaying a southwesterly direction.

The surface water off the northwest of New Zealand is of sub-tropical origin. As a result it is characterised by warmer temperatures and higher levels of salinity (Stanton, 1973). Localised areas of lower temperature and salinity can be caused by upwelling phenomena where deep water is pushed up towards the sea surface because of the bathymetry in the area or wind conditions (Garner, 1959). Upwelling has been consistently observed between the Three Kings Islands and between Manukau and Kaipara harbours (Garner, 1959, Ridgway, 1980, Stanton, 1973, Stanton and Hill, 1972).

Further south, the seasonal variation in the WAUC and WC currents results in variation in temperature and salinity off the Taranaki coastline. During the winter months, the WAUC (subtropical origin) extends further south pushing warmer more saline water to 39.3°S. In contrast, the WAUC is weaker in the summer months and the WC (sub-Antarctic origin) extends to 38°S bringing with it colder more saline waters and becoming the predominant current in the area (Ridgway, 1980, Stanton, 1973). In the Taranaki area, additional areas of cold surface water can also be found but these are thought to be caused by land water run-of as no evidence of upwelling has been found (Ridgway, 1980).



Figure 13: Ocean Circulation around the New Zealand coastline (Source: http://www.teara.govt.nz/en/map/5912/ocean-currents-around-new-zealand)



MSL characterised the current regime using maps for three different depths (10 m below the sea surface, 500 m below the sea surface and 1,000 m below the sea surface) (<u>Figure 14</u>, <u>Figure 15</u>, Figure 16).

The mean current speed over the period 1984-2013 at 10 m below sea surface shows typical values of 0.13-0.19 m/s at the representative hindcast locations P1, P2, P3 and P4, while stronger currents were observed on the eastern regions of the basin, due to strong northward flows following the isobaths along the western New Zealand's seaboard (Figure 14).

The mean current speed over the period 1984-2013 at 500 m shows typical values of 0.06-0.12 m.s⁻¹ at the representative hindcast locations P1, P2, P3 and P4, while stronger currents were also observed on the eastern regions of the basin along the western NZ's seaboard (Figure 15).

The mean current speed over the period 1984-2013 at 1,000 m shows typical values of 0.04-0.12 m.s⁻¹ at the representative hindcast locations P1, P2, P3 and P4, while stronger currents were observed on the southwestern and northeastern regions of PPP 56377 (Figure 16).

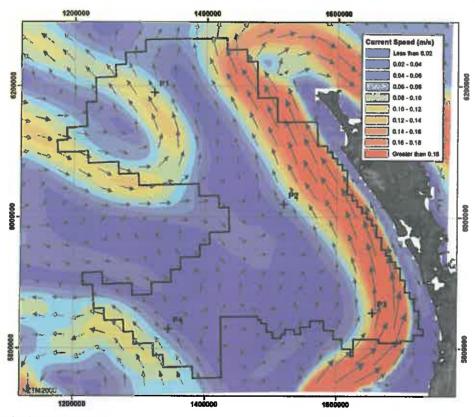


Figure 14: Mean total current flow at 10 m below sea surface (1984-2013)



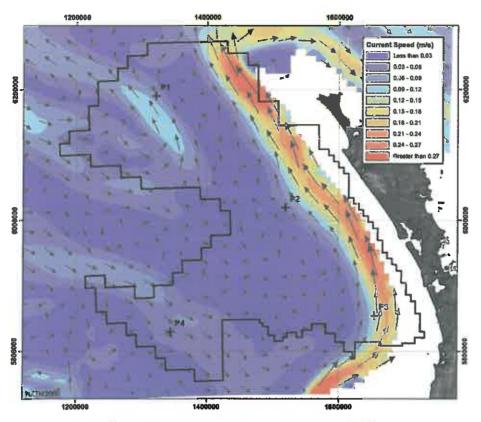


Figure 15: Mean total current flow at 500 m below sea surface (1984-2013)

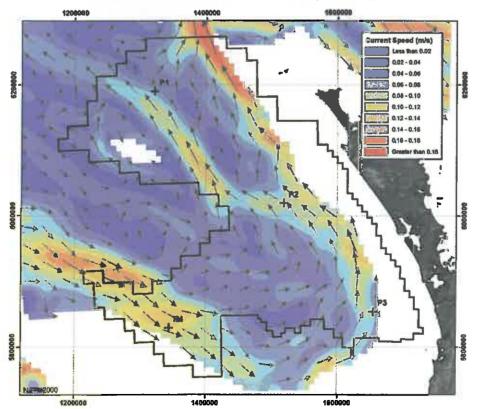


Figure 16: Mean total current flow at 1,000 m below sea surface (1984-2013)



4.1.2.2 Thermoclines and Sea Surface Temperature

During spring and summer thermal stratification of the water column becomes evident 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 weather conditions, with storm conditions causing significant vertical mixing and breakdown of thermal structure. Likewise the local environmental conditions can also play a part in formation of thermoclines such as tides and currents. As a result a well-defined thermocline is not always present.

Thermoclines can be observed through processed seismic data, where a thermocline can be characterised by a negative sound speed gradient, so the thermocline reflects an acoustic signal off this layer in the ocean. This is a result from a discontinuity in the acoustic impedance of water created by the sudden change in density which is derived from temperature differences. As water temperature decreases with depth, the speed of sound decreases, where a change in temperature of 1°C can result in a change of speed by 3 ms⁻¹ (Simmonds *et al.*, 2004).

There is a large range of water temperatures across the NWF Operational Area throughout the year due to the geographic extent.

In the STLM undertaken by Curtin University (<u>Appendix 5</u>), a representative sound velocity profile for the autumn months of the southern hemisphere was used to capture the worst-case environmental conditions that could be encountered towards the end of the proposed survey, including the presence of a thermocline. A sound velocity profile was obtained from the nearest grid point of the World Ocean Atlas. There is a strong seasonal thermocline in the upper part of the water column that results in a downwardly refracting near-surface sound speed profile in spring and summer, a weak surface duct in autumn, and a strong surface duct in winter. As a result a near-surface acoustic source would be expected to produce its lowest long range levels in spring and summer, moderate levels in autumn, and its highest levels in winter (Koessler & Duncan, 2014).

4.1.2.3 Wave Climate

MSL provided annual wave roses for locations P1, P2, P3 and P4 within PPP 56377. The predominant wave direction is from the south-southwest quarter for all modelled locations (<u>Figure 17</u>, <u>Figure 18</u>, <u>Figure 19</u>, and <u>Figure 20</u>). Mean significant wave height averaged over all years between 1979 and 2013 is highest in location P4, reaching 3.13 m; followed by an average mean significant wave height of 2.87 m in both P1 and P2; and 2.79 m in P4.

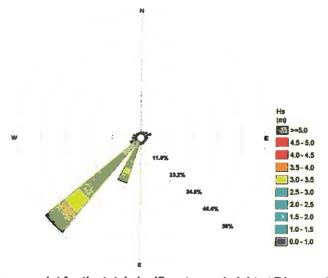


Figure 17: Annual wave rose plot for the total significant wave height at P1 - southern end of PPP 56377



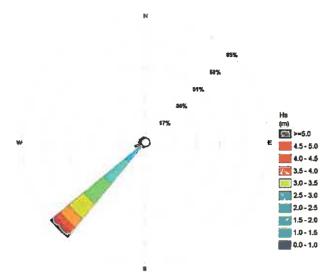


Figure 18: Annual wave rose plot for the total significant wave height at P2 - centre of PPP 56377

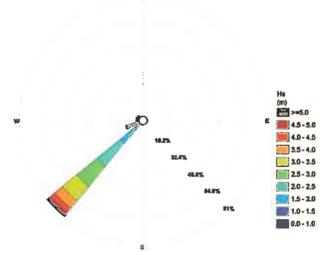


Figure 19: Annual wave rose plot for the total significant wave height at P3 - southeast end of PPP 56377

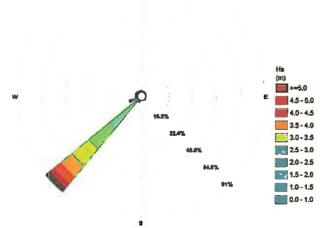


Figure 20: Annual wave rose plot for the total significant wave height at P4 - southwest end of PPP 56377

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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 (Ara, 2009).

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 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 (Ara, 2009).

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 (<u>Figure 21</u>) 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 deepwater basins offshore (<u>Figure 21</u>).

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 licenced for exploration.





Figure 21: NZ Sedimentary Basins.

(Source: GNS)

4.1.3.2 Features of the TGS 2D area of survey

In the area of the NWF Operational Area, bathymetric data indicates a continental shelf 25-30 Nm wide west and north of Cape Reinga, narrowing to 5 Nm off North Cape. The shelf edge, at about 150 m water depth is cut by several submarine canyons and one of these, North Cape Canyon, extends to within 2 Nm of the coast (Summerhayes, 1969). Further south, the Taranaki Continental Shelf has a 150 km wide opening to the Tasman Sea, occupying 30,000 km², and slopes gently towards the west with an overall gradient of <0.1° and locally less than 0.5° (Nodder, 1995).

Although the bathymetry throughout and surrounding the NWF Operational Area has a low overall gradient, there are numerous undulations, which give rise to a complex bathymetry including multiple basins, ridges and seamounts.



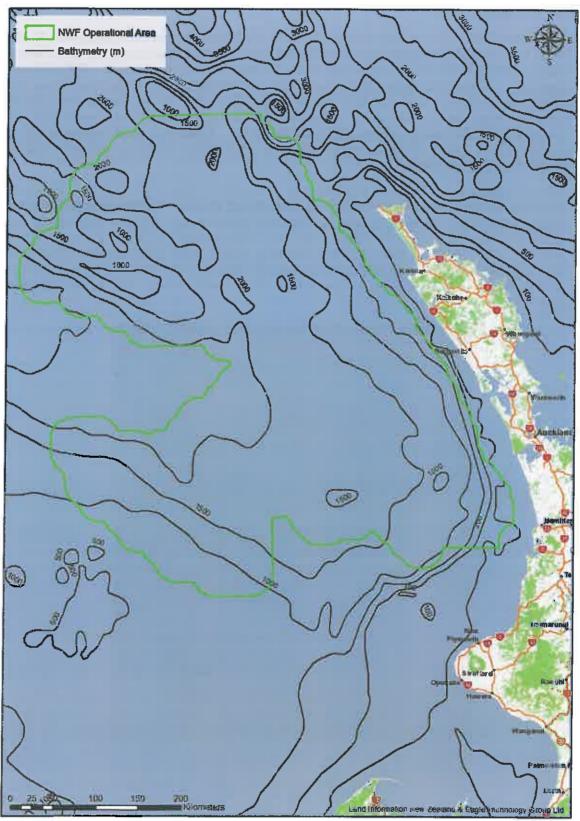


Figure 22: Bathymetry map of the NWF Operational Area



4.1.3.2.1 Taranaki Basin

The Taranaki Basin lies at the southern end of a rift that developed sub-parallel to the Tasman Sea rift and now separates Australia and New Zealand. It occupies the site of a late Mesozoic extension on the landward side of the Gondwana margin, covering ~ 330,000 km² (Figure 21). Within the basin, the structure is controlled by the movement along the Taranaki, Cape Egmont and Turi fault zones (Figure 23). It is a Cretaceous and Tertiary sedimentary basin where there is a grading from fine to medium sand to silt and muds with an increasing depth range across the Taranaki shelf. Prevailing west-southwest storm generated waves and currents are most likely the predominant sediment transport agents along the Taranaki coastline.

Petroleum exploration in Taranaki first began in 1865 with the Alpha-1 well in New Plymouth which is the first recorded well to produce oil in the British Empire. Petroleum activities in the Taranaki Basin have since increased to over 400 offshore and onshore exploration and production wells drilled. Over the years, there have been a large number of 2D and 3D MSS around NZ. The proposed NWF 2D MSS will help gather more subsurface information to build onto the existing knowledge within the NWF Operational Area and underlying strata and tie in to the existing data from the previously drilled wells (Waka Nui-1, Tarapunga-1, Korimako-1).

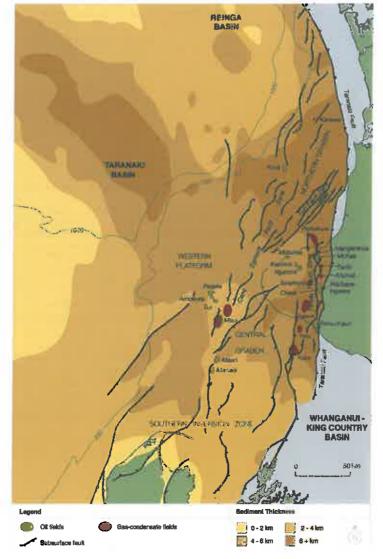


Figure 23: Taranaki oil and gas fields



4.1.3.2.2 Northland Basin

The Northland Basin is part of the Taranaki Basin and lies to the west of the Northland peninsula (Figure 21). It is bound by the prolongation of the West Norfolk Ridge to the southwest and the Northland Peninsula to the northeast (Bache *et al.*, 2012). It shares many features with the Taranaki Basin. Six petroleum systems are known to be present in the Northland region, two of which are known to be active (Uruski *et al.*, 2004).

4.1.3.2.3 Reinga Basin

The Reinga basin is a 740 km long sedimentary basin trending northwest, southeast from the basement outcrop in onshore Northland, to the Norfolk Ridge covering ~170,000 km². The Northland Peninsula and Reinga Ridge lie to its east and the Wanganella and West Norfolk Ridges lie to its west. To the north, it is separated from the South Norfolk Basin and the Three Kings remnant arc by the Veining-Meinesz Fracture Zone (Bache et al., 2012, Herzer et al., 1997). At its southeastern tip, the Reinga Basin is contiguous to the Northland Basin (Bache et al., 2012).

The basin is part of a region characterised by ridges and sedimentary basins which have undergone Cenozoic tectonic events and fragmentation of Gondwana since Cretaceous time. These have resulted in the creation of two distinct structural regions within the Reinga Basin. The southeastern domain which contains northwest striking extension structures and the northwestern domain which contains folds and normal faults have been inverted by compression tectonics. Seismic profiles of the Reinga Basin show well defined layering in the sediment profile resembling that of the New Caledonia Basin towards the southeast (Bache et al., 2012).

Seismic exploration of this basin commenced in the 1960s and comparatively to the Taranaki Basin, has had very little exploration. However, maturation models predict petroleum generation in this area would have begun in early Cenozoic time and the expulsion would continue to present day (NZP&M, 2013).

4.1.3.2.4 New Caledonia Basin

The New Caledonia Basin, flanked by the Norfolk Ridge and the Lord Howe Rise (<u>Figure 24</u>), forms a flat-floored area which slopes towards New Caledonia. At its widest section, it is divided into an eastern and a western basin by a shallower zone (van der Linden, 1970).

The Aotea seamount is located in the New Caledonia Basin where it rises 700 m from the sea floor. The seamount is a regular mass seven miles wide, elongated in an east-northeast direction for at least 30 miles (Brodie, 1965).

4.1.3.2.5 Norfolk Basin

The Norfolk Basin is the area delimited by the Cook Fracture Zone to the north, the Vening Meinesz Fracture Zone to the south and the Three Kings Ridge to the east (Sdrolias *et al.*, 2004, Launay *et al.*, 1982). The basin is split in two by a bathymetric discontinuity which separates the North Norfolk Basin and the South Norfolk Basin. The South Norfolk Basin is larger (200 km wide by 500 km long) and deeper (4,000 m) than the North Norfolk Basin.

Sedimentary cover varies in this region; ranging from thick cover on the Three Kings Ridge to a shallow cover in the Norfolk Basin (Launay *et al.*, 1982).

4.1.3.2.6 Lord Howe Rise

Lord Howe Rise is the main elevation in the Tasman Sea and extends from the Coral Sea Platform near New Caledonia to New Zealand (<u>Figure 24</u>). The southeastern section of the Rise forms the Challenger Plateau. The rise has a smooth, relief particularly towards the New Caledonia Basin (van der Linden, 1967).



Seismic surveys have demonstrated that this topography is the result of an irregular acoustic basement overlain by flat lying sediments. The upper sedimentary layers tend to thin towards the crest of the rise and the flanks of the rise are formed partially by wedges of sediments (Davey, 1977). Sedimentation rates across the rise are variable with higher sedimentation across the western flank contributing to producing an unusually thick sediment layer in this area (Eade and van der Linden, 1970). In addition, turbidity currents from the western flank are thought to supply sediments to the Tasman Sea floor (Conolly, 1969). Seamounts are scattered along the length of the rise but none are within the NWF 2D Operational Area (van der Linden, 1967).

4.1.3.2.7 Norfolk Ridge

The Norfolk Ridge runs parallel to the Lord Howe Rise (<u>Figure 24</u>) and is double-crested creating the Wanganella Ridge to the east and, the slightly lower, West Norfolk Ridge to the west. The Wanganella Basin is situated between these two ridges (Herzer *et al.*, 1997).

The Norfolk Ridge has bolder relief than the Lord Howe Rise (van der Linden, 1967), and the southwestern margin in particular has a very steep profile (Davey, 1977). Sedimentary cover is variable along the surface of the ridge, ranging from areas of no sedimentary cover to ponding of sediments between outcropping basement highs on the crest of the ridge (e.g. Wanganella Basin (Davey, 1977, Herzer et al., 1997).

The Norrie Seamount is situated on the western slope of the Norfolk Ridge and it rises 1,200 m from the sea floor (van der Linden, 1970).

4.1.3.2.8 Reinga Ridge

The Reinga Ridge forms the eastern limit of the Reinga Basin (<u>Figure 24</u>). It is mainly a complexly faulted and uplifted piece of the basin which exhibits the same sedimentary sequence as the Reinga Basin itself. In the southeast, the ridge becomes more pronounced developing into a major basement ridge as it passes onto the Northland continental shelf (Herzer et al., 1997).

4.1.3.2.9 Maria Ridge system and Three Kings Islands

Extending 100 miles off New Zealand, the Maria Ridge is thought to be a prolongation of the Northland Peninsula (Summerhayes, 1969). At its southern extremity, the ridge splits into the North Maria Ridge and the South Maria Ridge.

South Maria Ridge is a prominent feature of the sea floor and does not exceed depths of 500 m (Summerhayes, 1969, Nelson and Hancock, 1984). To the east, it is flanked by the flat-floored Three Kings Trough which lies at 750 m depth and separates it from the North Maria Ridge. To the south of the ridge, lies the Karetu Trough which separates it from the Reinga Shelf (Summerhayes, 1969). The South Maria Ridge is characterised by areas of extremely rugged bathymetry and sees the Three Kings Islands (Manawatawhi) rising from a flat bank on its summit (Summerhayes, 1969). The Three Kings archipelago consists of a large island (Great Island) and three smaller islands (Southwest Island, West Island, Northeast Island) and a series of islets and rock stacks situated 48 km northwest of Cape Reinga. They separated from the continent 1.8 to 5.4 million years ago (DOC, 2014c).



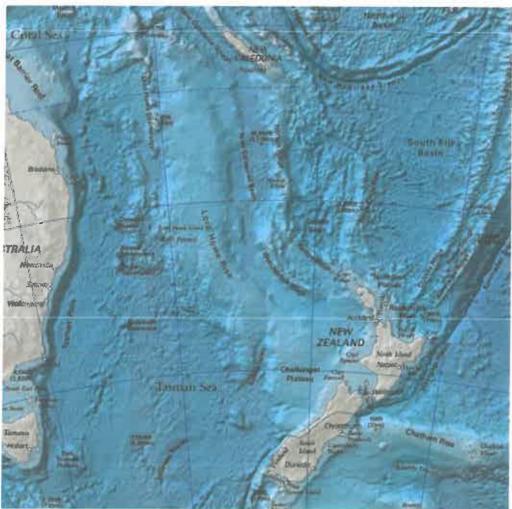


Figure 24: Southwest pacific basin (Source: www.oceana.org)

4.2 Biological Environment

4.2.1 Planktonic Communities

Within NZ, the productivity of the ocean is a result of many factors; namely ocean currents, climate and bathymetry which causes upwelling creating nutrient rich waters — ideal conditions for plankton growth and the animals that feed on them (MPI, 2014b).

Plankton are a drifting organism (animals, plants or bacteria) that occupy the pelagic zone of oceans and seas 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 microscopic plants which capture energy from the sun and take in nutrients from the water column via photosynthesis. They create organic compounds from CO₂ dissolved in the ocean and help sustain the life of the ocean; and



Zooplankton – consisting of small protists, metazoans (i.e. crustaceans), larval stages of fish and crustaceans which feed on the phytoplankton and bacterioplankton. Although zooplankton are primarily transported by ocean currents, many are able to move, generally to either avoid predators or to increase prey encounter rates. Zooplankton primarily live in the surface waters where food resources are abundant.

In recent years, satellite imagery has been used to examine primary productivity in the oceans around NZ (using Chlorophyll α as a proxy for primary productivity). The images show evidence of great seasonal and regional variation within the NWF 2D Operational Area. A consistent annual phytoplankton bloom takes place in the spring months off the northwest of New Zealand. Chlorophyll α levels then proceed to drop to their lowest annual level at the end of the summer and build up again throughout the winter in order to peak once again with the onset of spring. It is widely accepted that high levels of primary productivity will have a knock-on effect up the food chain attracting predators to feed in the area.

Regional variations in observed primary productivity are broadly linked to topography, and local wind and currents which induce upwelling. This is most notably the case around the Three Kings Islands (Murphy *et al.*, 2001). Upwelling in this area has been well documented and is known to influence the local ecological landscape (Garner, 1959, Stanton, 1973). The Taranaki Bight also displays increased primary productivity in comparison with more northerly offshore areas (Murphy *et al.*, 2001). This particular upwelling and associated euphausiid (krill) bloom is of particular relevance to the MMIA as it has been recently discovered to attract feeding blue whales (see Section 4.2.4.4.2).

4.2.2 Invertebrate Communities

Worldwide, invertebrates consist of approximately 34 major groups, 10 major phyla and 23 minor phyla. The Arthropoda phylum includes the majority of the one million animal species described. The next largest phyla are Mollusca, Protista, Nematoda, Platyhelminthes, Cnidaria, Annelida, Echinodermata, Porifera and Bryozoa (Marsden and Schiel, 2007).

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.

The coastal area in the vicinity of the NWF Operational Area presents a wide range of coastal environments (Hume *et al.*, 1992) which vary in exposure to wave action, substrate (reefs, boulders, sand etc.), coastal morphology (harbours and estuaries) and temperature (see <u>Section 4.1.1</u>). These factors directly impact the occurrence of various species within the intertidal zone. Overall, molluscs tend to dominate rocky shores, while mobile invertebrates are often the most commonly observed in soft shores. On hard shores, sessile invertebrate species (i.e. sponges, ascidians, bryozoans, and hydroids) are conspicuous and form stable communities (Lavery *et al.*, 2007).

Similarly to the intertidal, the deeper subtidal and abyssal zones within the NWF Operational Area present a wide range of habitats (seamounts and ridges, rocky reefs, hard and soft substrate) 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.

In 2013, NIWA published a report defining "sensitive marine benthic habitats" within the NZ EEZ. For the purpose of the report, "sensitivity" was defined as "tolerance of a species or habitat to damage from an external factor" and "the time taken for its subsequent recovery from damage sustained as a result of an external factor". The following list includes the habitats from the report which can be found within the NWF Operational Area.



- Beds of large bivalves are recognised as ecosystem engineers because of their impact on the seabed community composition and the role that they play in nutrient cycling. Suspension feeding bivalves are common off Northland and the west coast of the North Island to mid-shelf depths (Rowden et al., 2012).
- New Zealand has 38 species of brachiopods including 18 species which are endemic (Macfarlan et al., 2009). Brachiopod beds occur at all depths on hard substrates in areas of significant water movement (Macfarlan et al., 2009).
- **Bryozoan beds** are known to provide habitats for many other organisms (Wood *et al.*, 2012). They are found most commonly on temperate continental shelves (MacDiarmid *et al.*, 2013).
- Calcareous tube worm thickets or mounds are most common in coastal waters. The northern limit of their range is the Taranaki Coast (Davidson et al., 2010).
- Chaetopteridae worm fields are known to provide biogenic habitat for other species
 although this has not been demonstrated in NZ waters. This type of worm field has
 been found off the South Island and it is thought that it may also occur in the coastal
 and shelf waters of the North Island (MacDiarmid et al., 2013).
- Macro-algal beds occur within the photic zone to depths of around 200 m and are widespread around NZ. They capture energy via photosynthesis, provide three dimensional structure to the marine habitat and have a major role in carbon cycling (MacDiarmid et al., 2013).
- Rhodolith (maerl) beds provide a varied habitat and support a wide range of species. Little is known of their occurrence within the NZ EEZ but they are thought to be present within the photic zone in areas of strong current (MacDiarmid et al., 2013).
- Sea pen fields occur in deep waters (continental shelf, slop and abyssal plains) with low turbulence but sufficient current to ensure a flow of plankton across their polyps (MacDiarmid *et al.*, 2013).
- **Sponge gardens** are hotspot regions of high sponge density. These occur frequently within the NZ EEZ and include amongst others Spirits Bay rocky reef, Three Kings subtidal rocky reef, Turnip and Onion soft sediment sponge gardens in Spirits Bay, and Pariokariwa Reef (Parininihi Reserve) (MacDiarmid *et al.*, 2013).
- Stony coral thickets or reefs are known to provide habitat for fish and invertebrate species. They are particularly vulnerable to the impacts of fishing, drilling and mining and known to occur on seamounts and ridges within the NWF Operational Area (MacDiarmid et al., 2013).
- Seven species of **xenophyophore beds** occur in NZ including three endemic species. They act as passive particle traps and provide spatial complexity to the sea floor (Levin and Gooday, 1992). They are known to occur in the western continental slope of New Zealand (MacDiarmid *et al.*, 2013).

As mentioned above, 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.

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. Deepwater corals are fragile, sessile, slow growing and long-lived. They have limited larval dispersal and are restricted to certain habitats.



Cold water corals are known to occur in the NWF Operational Area through direct sampling (Figure 25, Figure 26, Figure 27, Figure 28, Figure 29, Figure 30) but the number and nature of these samples is insufficient to provide a full picture of the occurrence of these species. 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, black corals and stony corals off the west of Northland and over the West Norfolk Ridge. Hydrocoral occurrence was predicted to be high off the northern tip of Northland around the Three Kings Islands. Further details on the effects of seismic activities on corals is provided in Section 5.1.2.4.3.

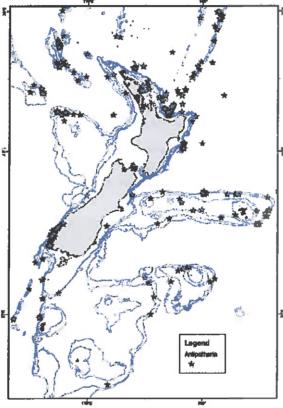


Figure 25: Known localities of black corals within the NZ region (Consalvey *et al.*, 2006)



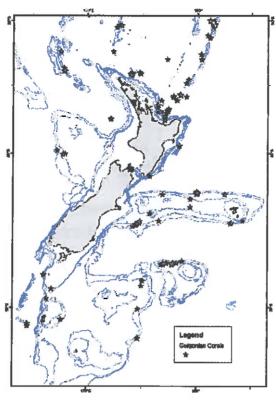


Figure 26: Known localities of gorgonian corals within the New Zealand Region (Source: Consalvey *et al.*, 2006)

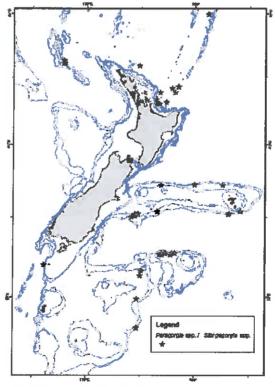


Figure 27: Known localities of bubblegum corals within the New Zealand region (Source: Consalvey *et al.*, 2006)



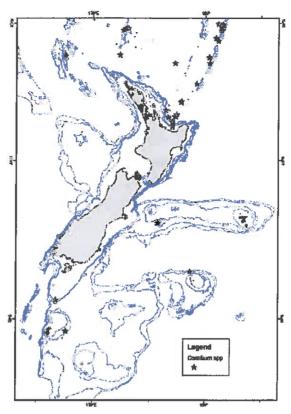


Figure 28: Known localities of precious coral within the New Zealand region (Source: Consalvey *et al.*, 2006)

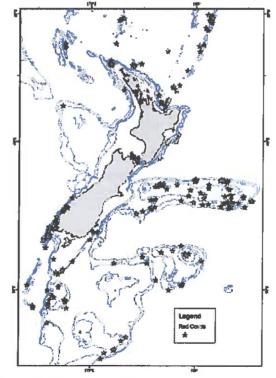


Figure 29: Known localities of red coral within the New Zealand region (Source: Consalvey *et al.*, 2006)



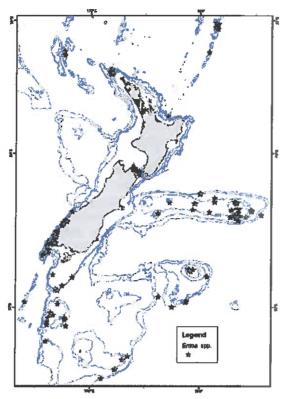


Figure 30: Known localities of all red hydrocoral within the New Zealand region (Source: Consalvey *et al.*, 2006)

4.2.3 Fish Species

The northwest 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 TGS's PPP 56377 for all commercial fishing effort that took place within the period 2008-2013. This assessment identified jack mackerel and skipjack tuna as the two most commonly caught commercial fish species within this area. More detail on commercial fishing within PPP 56377 can be found in <u>Section 4.4.2</u>.



Table 7: Distribution of commercial fish species caught within the NWF Operational Area (MPI, 2014d)

Water column	Fish species caught between 2008-2013
Benthic	Jack mackerel, barracouta, frostfish, blue mackerel, snapper, trevally, ling, school shark, tarakihi, gurnard, blue cod, seal shark, ribaldo, silver dory, john dory, shovelnose dogfish, hagfish, spiny dogfish, porcupine fish, kingfish, rig, northern spiny dogfish, smooth skate, kahawai, common warehou, redbait, bass, hapuku, ghost shark, bluenose, rough skate, sea perch, arrow squid, Japanese gurnard, giant stargazer, carpet shark, silver warehou, leather jacket, unicorn rattail, eagle ray, rays, rattails, hairy conger eel, gemfish, rudderfish, whiptail ray, ruby fish, conger eel, spotted stargazer, javelin fish, short-tailed black ray, mirror dory, lancet fish, longnosed deepsea skate, flatfish, sand flounder, brill, electric ray, scaly gurnard, yellow boarfish, broadnose sevengill shark, hoki, lemon sole, yellow-eyed mullet, brown stargazer, orange perch, lanternfish, red snapper, yellowbelly flounder, blue moki, octopus, slickheads, porae, turbot, orange roughy, johnson's cod, baxter's lantern dogfish and smooth oreo.
Pelagic	Striped marlin, blue marlin, bronze whaler shark, swordfish, thresher shark, bigeye tuna, albacore tuna, skipjack tuna, blue shark, mako shark, porbeagle shark, slender tuna, southern bluefin tuna, moonfish, rays bream, pilchard, oilfish, and pacific bluefin tuna.

4.2.3.1 Protected fish species

Schedule 7A of the Wildlife Act 1953 lists eight species of fish as protected, all of which can be found either within or in the vicinity of the NWF Operational Area. 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.

Collectively, the distribution of these protected species spans the entirety of the NWF Operational Area.

Great white sharks occur throughout NZ waters 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, where 35 great white sharks have been tagged since 2005 and 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, 2014k). 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 and could occur off Taranaki, to the south of the NWF Operational Area (DOC, 2014a).

The remaining species occur in warmer waters and could be found within the northern portion of the NWF Operational Area.

The deepwater nurse sharks are found in most warm temperate and tropical regions. Generally, this species congregates around the edges of the continental shelf, the upper continental slopes, oceanic ridges and seamounts all of which occur within the NWF Operational Area (DOC, 2014b).

Manta ray, spiny tailed devil ray and oceanic white-tips can be found off the northeast coast of the North Island (DOC, 2014g, DOC, 2014e).



Black grouper occurs off northern NZ in particular around the Three Kings Islands. It is classified as near threatened by the IUCN (DOC, 2014h).

Whale sharks are rarely seen in New Zealand waters but tend to occur off the northeast of the North Island up to the Three Kings Islands in water temperatures between 21-23°C. Sightings of this species peak in the summer months (November-March) and tend to be concentrated around the major current systems (DOC, 2014).

4.2.4 Cetaceans

Forty-one species of dolphins and whales can be found in NZ, which is over half of the world's cetacean species (Suisted and 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 (Department of Conservation (DOC), 2007). In contrast, odontocetes have teeth; they are highly social; and they will 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 NWF 2D 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 studied. 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.

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 complementary to detections (acoustic and visual) of live animals.

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 NWF Operational Area; however, the available data for some species is limited due to



logistical limitations mentioned above. Consequently, the cetacean sightings data collected during the NWF 2D MSS will be invaluable towards enhancing available baseline information within the NWF Operational Area and in turn will contribute to effective monitoring of vulnerable species.

4.2.4.1 Sightings and strandings within and surrounding the NWF Operational Area

The data sources accessed in order to identify cetaceans potentially present within the NWF 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.

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.

A 10 day multi-beam survey was conducted in PEP 55781 within the NWF Operational Area, commencing 4 June 2014 and a MMO was onboard for the duration of the survey as well as the transit to and from Wellington. A total of 83 hours and 20 minutes of daylight observations were undertaken from the *R.V. Tangaroa* within PEP 55781. Six sightings were made within PEP 55781 and comprised of five distant unidentified baleen whales (*Balaenoptera* spp.) and a humpback whale.

The marine mammal species identified as potentially being in the NWF Operational Area at some stage during the year are listed in <u>Table 8</u>. A basic ecological summary for each of the more common species likely to be within the NWF Operational Area is included in <u>Section 4.2.4.4</u>.



Table 8: Cetaceans likely to be present in or around the NWF Operational Area

М	ysticeti (Baleen whale su	iborder)
Balaenidae (Right whale family)	Baleanoptera (Rorqual family)	
Southern right whale (Eubalaena australis)	Minke whale (Balaenoptera acutorostrata & B. bonaerensis)	Blue whale (Balaenoptera musculus)
Pygmy right whale (Caperea marginata)	Sei whale (Balaenoptera borealis)	Fin whale (Balaenoptera physalus)
	Bryde's whale (Balaenoptera edeni)	Humpback whale (<i>Megaptera novaeangliae</i>)
Odo	entoceti (Toothed whale s	suborder)
Delphinidae (Dolp	Physeteridae (Sperm whale family)	
Hector's dolphin, Maui's dolphin (Cephalorhynchus hectori; Cephalorhynchus hectori maui)	Dusky dolphin (Lagenorhynchus obscurus)	Sperm whale (Physeter macrocephalus)
Common dolphin (Delphinus delphis)	Southern right whale dolphin (Lissodelphis peronii)	Pygmy sperm whale (Kogia breviceps)
Pygmy killer whale (<i>Feresa</i> attenuate)	Killer whale (Orcinus orca)	Dwarf sperm whale (Kogia sima)
Melon-headed whale (Peponocephala electra)	Spotted dolphin (Stenella attenuata)	
Long-finned pilot whale (Globicephala macrorhynchus)	Striped dolphin (Stenella coeruleoalba)	
Short-finned pilot whale (Globicephala macrorhyncus)	Long-snouted spinner dolphin (Stenella longirostris)	
Risso's dolphin (<i>Grampus</i> <i>griseus</i>)	Rough-toothed dolphin (Steno bredanensis)	
False killer whale (<i>Pseudorca</i> crassidens)	Bottlenose dolphin (Tursiops truncates)	
Zi	phioidea (Beaked whale t	family)
Arnoux's beaked whale (Berardius arnuxii)	Blainville's beaked whale (Mesoplodon densirostris)	True's beaked whale (Mesoplodon mirus)
Southern bottlenose whale (Hyperoodon planifrons)	Gray's beaked whale (Mesoplodon grayi)	Shepherd's beaked whale (Tasmacetus shepherdi)
Andrew's beaked whale (Mesoplodon bowdoini)	Strap-toothed whale (Mesoplodon layardii)	Cuvier's beaked whale (Ziphius cavirostris)
Pygmy beaked whale (Mesoplodon peruvianus)	Hector's beaked whale (Mesoplodon hectori)	
 -		



4.2.4.2 Migration paths near the NWF Operational Area

During spring most of the baleen whales living 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) (Department of Conservation (DOC), 2007). The distribution and migration paths around NZ for humpback, sperm, Bryde's and southern right whales are shown in Figure 31 and further summarised in Section 4.2.4.4. The northern migration routes back up to the Pacific Islands are relatively well known, however the southwards routes are not. The NWF 2D MSS is currently expected to start at the beginning of December 2014, and running until March/April 2015; therefore it is considered that NWF 2D MSS will be complete prior to the northward migrations of whales. However, if there are believed to be large numbers of migratory whales within the NWF Operational Area, DOC would be notified and any additional mitigation measures would be discussed between DOC and TGS.



Figure 31: Whale distribution and migration pathways in NZ waters (Te Ara, 2014e)

4.2.4.3 Protected cetacean species in the NWF Operational Area

Eight species of marine mammal are included in the NZ threat classification list, either as "nationally critical", "nationally endangered" or "range restricted" (<u>Table 9</u>) (Baker *et al.*, 2010). Six of these species have been identified as potentially being present within the NWF Operational Area during the NWF 2D MSS (Bryde's whale, killer whale, Maui's dolphin, southern right whale, Hector's dolphin and bottlenose dolphin).



Manne Mammal Species	NZ Threat Classification	IUCN Classification	Summary	Distribution	Likely to be in Survey Area
Bryde's whale (Belsenopters edeni)	Nationally critical	Data deficient	Generally a coastal species but does live in the open ocean. Bryde's whales prefer temperate waters and are observed off the NZ coast generally north of the Bey of Plenty. This species of whale is believed to rarely venture beyond 40 dugrees south.	Have a preference for warmer waters. Has the potential to be observed in the northern part of the NWF Operational Area.	1
Killer whale (Orcinus orca)	Nationally critical	Data deficient	Feeds on a variuty of enimals which include other marine mammals and fish species. They are believed to bread 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. Allier wheles are widely found in all occeans of the world although mure dominant in cooler waters. Ulkely to occur in the southern part of the NWF Operational Area.	~
Maui's dolphin (Cephalorhynchus hectori muui)	Nationally critical	Critically endangered	Warld's smallest dolphin and only found in inshore waters on the west coast of the North Island of N7. Considered a subspecies of Hector's dolphin, the Mauit's dolphin is listed as critically enteringered under the IUCN Rediat. In 2012, a DOC commissioned genetic study estimated the Mauit's dolphin population to consist of approximately 55 individuals over one year of age (95% Ct. 48-69) (Harmer et al., 2012). These results suggests a slow decline over the past decade (-3% per year). The close inshore distribution of Mauit's dolphin overlaps with many coastal activities that pose a threat to their survival. As such, there are a number of human and non-human related threats that risk impacting the dolphins' survival.	Generally live close to shore (within 4 Nm) although sightings further offshore have been reported. Only found on west coast of the North Island. Possibly observed in the NWF Operational Area.	,
Southern elephant seal (Mirounga & onina)	Nationally critical	Least concern	They are the largest species of seal and fued on squid, cuttlefish and large fish. Generally only comes ashore in spring/summer on offshore islands and some mainland areas to breed and moult, otherwise fives mostly at sea. They have an inflatable proboscis (snout) which is most present in adult makes which is meant to increase the bull elephant seals roar.	Primery range Includes the Antipodes, Campbell, Auckland, Snares Islands and the surrounding Southern Ocean. Occasionally they are found on the mainland from Stemart Island to the Bey of Islands. Unlikely to occur in the NWF Operational Area.	×
Southern right whale (Eubelaena au-trelis)	Nationally endangered	Least concern	Present both offshore and inshore and their diet consist of foil, particularly copepeds. Mat's and calve during wither months in sheltered sub Antarctic harbours such as Ausdeland Islands and Campbell Island. Fire baleen feeders and often travel well out to sea during freding season; but they give birth in coestal areas (American Cetacean Society, 2010).	Likely to occur as a transient species in the NWF Operational Area.	,
Hector's dolphin (Cephalarhynchus hectori)	Nationally endangered	Decressing	The smallest dolphin species (less than 1.5m long). Generally live inshore although have been sighted up to 20 Nm from the coast. The Hector's dolphin is listed as endangered under the IUCN Redist.	Patchilly distributed around the South Island coast. On east coast live between Banks Peninsuls and Te waswes Bay and Parpicise Bays in the south. There are also populations around Kalkoura and Cloudy BayMariborough Sounds. There has been eightings of this species in the Southern Terenatic Bight as well as strandings along the Terenatic constitue. Prossbly observed in the NNY Operational Area although this species will be difficult to distinguish from Mauris childhin in the field.	,
NZ sea lion (Phocarctos hookeri)	Nationally critical	Decreasing	Feeds on fish, invertebrates, and occasionally birds or other seals. Breeding occurs in summer months with pupping occurring in December/Jenuary with the pups being weaned in July/August.	Known to forage along continental shelf breaks with primary range including the Auckland, Campbell, and Shares Islands. Unlikely to be encountered in the NWF Operational Area.	ä
Bottlenose dolphin (Tursiops truncelus)	Nationally endangered	Least concern	Are found worldwid: in temperate and tropical waturs, generally north of 45 degrees south. Population density appears to be higher near shore. Resident buffences delphins are found off the east coast of the North Island, the northern tip of the South Island, and in Doubtful Sound.	Possibly observed in the NWF Operational Area.	1

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4.2.4.4 Ecological summary of commonly occurring cetacean species in the NWF Operational Area

4.2.4.4.1 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 rounded and they have unusually long pectoral fins. The top of the humpback's head and lower jaw have rounded bump-like knobs called tubercules. Each tubercule has at least one stiff hair which is believed to help detect movement in nearby waters.

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 between 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.

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 (Shirihai, 2002, Dawbin, 1956). 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 and Childerhouse, 2000).

Both male and female humpback whales vocalise for communication, but only males produce 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).

Humpback whales can dive for up to 40 minutes down to depths 150 m; however, dives generally only last for up to 15 minutes (Shirihai and Jarrett, 2006).

Whaling in the southern hemisphere reduced the population from ~120,000 animals to 15,000 but the population is now currently recovering (Suisted and Neale, 2004).

Four humpback whales have previously been observed within the NWF Operational Area as well as a stranding south of the Waikato River mouth. However, given the anticipated commencement of the NWF 2D MSS, most humpback whales are likely to still be in Antarctic waters. Humpback whales do use the NWF Operational Area as part of their migratory pathways, although during the NWF 2D MSS (December – March/April) it is less likely that humpback whales will be observed.

4.2.4.4.2 Blue Whale

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 (Todd, 2014, Baker, 1999). 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 and can reach up to 12 m (Shirihai and Jarrett, 2006).

Two subspecies of the 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 will often rely on acoustics or genetic sampling to confirm identification of animals to sub-species level (Attard et al., 2012, Samaran et al., 2010).

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, Department of Conservation (DOC), 2007), therefore large aggregations of food in upwelling areas are important 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 vocalisations are also the loudest of any animal, where their calls can reach levels of up to 188 dB (Aroyan et al., 2000, Cummings and Thompson, 1971)

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 relatively lower levels of sea surface temperature and high concentrations of euphausiids (Burtenshaw et al., 2004, Croll et al., 2005, Fiedler et al., 1998, Gill et al., 2011).

Torres (2013) published a paper on a previously unrecognised blue whale foraging ground in the South Taranaki Bight and proposed that the animals observed in the South Taranaki Bight could 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).

In contrast, strandings generally enable the identification down to sub-species level. Four pygmy blue whales are recorded on the DOC stranding database from the coasts of Taranaki, Wellington, Tasman Bay and Auckland. The most recent pygmy blue whale strandings were of a 20 m specimen at Himatangi Beach near Wellington in October 2013, and a 19.5 m specimen at Tapuae Beach in July 2014.

In addition to the feeding ground off Taranaki Bight, there have also been acoustic detections of blue whales off Three Kings Islands, Great Barrier Island and off the east and west coast of the South Island (McDonald, 2006, Kibblewhite et al., 1967, Miller et al., 2013, Olson et al., 2013). While in 2014 feeding blue whales were also observed off the Waikato coast within PEP 38451, 36 km to the south of the NWF Operational Area during the Anadarko drilling campaign when MMO's were onboard during vertical seismic profiling.

Two blue whales have been observed within the NWF Operational Area in January 2013 while a seismic vessel with observers on was transiting to the Survey Area in north Taranaki waters, and one blue whale has stranded inshore of the NWF Operational Area on the Waikato coastline. Therefore there is the potential that blue whales will be observed during the NWF 2D MSS.

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.



4.2.4.4.3 Bryde's Whale

Bryde's whales are the most common and second largest baleen whale in NZ waters. This large rorqual can reach 15.6 m in length and weigh between 16-20 tonnes. They have a stream-lined body, an erect dorsal fin and present three rostrum ridges which are diagnostic of this species.

These whales are found most frequently in warmer waters and are known to feed on fish (pilchards, mackerel and mullet) but only rarely on zooplankton. In NZ, the Hauraki Gulf is a known year-round feeding ground and although some whales present limited seasonal migration, most have a restricted home range (Todd, 2014) (see Section 4.2.4.2).

Bryde's whales produce a 25-22 Hz down-swept call which has been recorded by a number of authors (Kibblewhite et al., 1967, McDonald, 2006). A second 22 Hz tonal call has also been associated to Bryde's whales in NZ waters, suggesting the existence of multiple stocks of this species (McDonald, 2006).

From the DOC sighting database there are no records of any Bryde's whales being observed within the NWF Operational Area; however, four sightings have been recorded in shallower waters inshore of the NWF Operational Area, and two stranding events have occurred inshore of the NWF Operational Area (1991 and 1995). Given Bryde's whales apparent coastal affinity from the DOC sighting database, it is unlikely that they will be present within the NWF Operational Area; however, given the NWF 2D MSS is being acquired during summer months there is the potential that Bryde's whales could be encountered within the NWF Operational Area when warmer waters are present.

4.2.4.4.4 Minke Whale

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 and 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.

There have been no sightings of minke whales within the NWF Operational Area, although there has been two strandings along the Northland coastline. Minke whales have been observed along Northlands east coast; however there is a lot more vessels out on the water in that area. Even though the NWF 2D MSS is being acquired during the summer months when the minke whales are in Antarctic waters, there are a number of observations in northern waters during summer months, therefore there is the potential that minke whales could be encountered within the NWF Operational Area.

4.2.4.4.5 Sei Whale

Sei whales can reach an average length of 15 - 18 m and 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 with the blow.

Sei whales are among the fastest swimming cetaceans. Swimming speeds of up to 50 km/hr have been recorded enabling animals to travel up to 4,320 km in ten days. During February-March, Sei whales migrate south to Antarctica where there is an abundance of food then return to the waters between the South Island of NZ and Chatham Islands to calve. No sei whales have been recorded on the DOC sighting database within the NWF Operational Area, although two sei whales have been sighted 35 and 90 km to the south of the NWF Operational Area. Likewise there have been no recorded strandings of sei whales inshore of the NWF Operational Area. Even though there has been no sightings within the NWF Operational Area, they have been sighted within the general area so there is the potential that they could be encountered during the NWF 2D MSS.

4.2.4.4.6 Southern Right Whale

Southern right whales can reach between $15-18\,\mathrm{m}$ 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/hr, making them vulnerable to ship-strikes and in the past, whaling.

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 sighting observations have been recorded outside of this period (see Section 4.2.4.2).

The population was heavily reduced by whaling which caused numbers to drop from ~17,000 to ~1,000 (Suisted and Neale, 2004, Carroll et al., 2011). 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.

Southern right whales are regarded as nationally endangered but this recent data indicates that they are making a recovery.

There have been no sightings of southern right whales within the NWF Operational Area; however, there have been three sightings inshore all close to the beach (Kaitaia and Auckland coastlines) and all during winter months. Given the timing of the NWF 2D MSS over summer months it is unlikely that a southern right whale would be encountered as they are likely to be in Antarctic waters feeding.

4.2.4.4.7 Beaked Whale

Due to the limited sightings at sea, very little is known about the distribution of beaked whales around the NZ coastline. 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 nearly 3,000 m (the Cuvier's beaked whale was



recently recorded as the deepest diving marine mammal with a dive to 2,992 m lasting 137.5 minutes (Schorr *et al.*, 2014)).

Offshore areas off the northwest of the North Island (referred to as the "west coast basin") are thought to be important for both Gray's and Shepherd's beaked whales (Arnold, 2013). There have been no sightings of any beaked whales within the NWF Operational Area; however, beaked whales are renowned for being difficult to observe at sea.

Along the coastline inshore of the NWF Operational Area nine species of beaked whales have been recorded from the DOC stranding database and include: Andrew's; Blainville's; Gray's; Hector's; Layard's/strap-toothed; Shepherd's; Cuvier's; Arnoux's and pygmy. A lot of the strandings have occurred over the summer months, however across all of the species the strandings have occurred throughout the year, so it is assumed they are present all year round. Therefore these beaked whales mentioned here as determined from DOC's stranding database, could be observed during the NWF 2D MSS.

4.2.4.4.8 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 food but they are also known to eat demersal fish (Torres, 2012). During summer month's sperm whales migrate to the poles, males more so than females and juveniles.

Sperm whales prefer the open ocean environment of shelf breaks and deep canyons at depths down to 1,000 m where dives can last for over an hour. No light can penetrate to these depths so sperm whales rely entirely on sound to locate their prey and navigate (Torres, 2012).

Sperm whales use clicking sounds to communicate and use echolocation to not only hunt for prey but to identity the other whales within their group, which can often allow the groups to coordinate foraging activities (Andre and Kamminga, 2000). It is believed that sperm whales can most likely determine the size, direction and distance of prey when they are hunting in the deep water where there is no light (Ocean Research Group, 2014). This echolocation will allow any sperm whales in the proximity to the *Aquila Explorer* 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.

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

Four sperm whales have been observed within the NWF Operational Area and four sperm whales have been observed directly to the south. Dating back to the 1960's there has been 45 sperm whale stranding events recorded inshore of the NWF Operational Area, suggesting this area of coastline is well inhabited by sperm whales. As a result there is the potential that sperm whales could be encountered during the NWF 2D MSS, even though it is believed that most sperm whales migrate to Antarctic waters during summer months, there have been a number of observations and stranding events during summer months.

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



They have a very timid behaviour, lack a visible blow, and with their low profile/appearance in the water are often difficult to observe at sea unless weather conditions are calm with little or no swell. Within the NWF Operational Area or west coast of the North Island there have been no recorded sightings on the DOC database. However, there have been strandings along the entire coastline inshore of the NWF Operational Area, with the strandings being spread throughout all seasons. As a result most of the knowledge on these whales is derived from stranded whales.

Therefore it is assumed that pygmy sperm whales may be present in the NWF Operational Area, although they could be difficult to observe in most sea conditions.

4.2.4.4.10 Dwarf Sperm Whale

Dwarf sperm whales (*Kogia sima*) are rare in NZ waters (Te Ara, 2014d) and are not often sighted at sea, so most of the known information comes from stranded whales. The dwarf sperm whales are the smallest species commonly known as a whale. They can grow up to 2.7 m in length and weigh up to 250 kg, which is smaller than some of the larger dolphins. These whales make slow, deliberate movements with little splash or blow and usually lie motionless when they are at the sea surface, making them hard to be observed in anything but very calm seas.

The dwarf sperm whale is very similar in appearance to the pygmy sperm whale, making identification difficult at sea; however, the dwarf sperm whale is slightly smaller and has a larger dorsal fin.

Feeding behaviour and target prey species are similar to that of the pygmy sperm whale but in shallower waters (Shirihai and Jarrett, 2006)

4.2.4.4.11 Hector's Dolphin

Hector's dolphins are an endemic species (only found in 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.

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, 2014c, 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 and 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 were 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, 2014c).

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 and Clement, 2013). In addition, a sighting of a Hector's/Maui's dolphin from the Maui platform in the South Taranaki Bight supports they can be found further offshore.

The DOC sighting database shows there have been four recorded Hector's dolphins sighted inshore of the NWF Operational Area; however, they have all been close to shore, within 1.5 km of the coastline. The DOC stranding database lists a number of Hector's dolphins that have stranded along the coastline and extend from Ninety Mile Beach in the north all the way down the coast to Taranaki.

It is possible that Hector's dolphins could be in these northern waters during the NWF 2D MSS; however, they are most likely to be in waters well inshore of the NWF Operational Area

4.2.4.4.12 Maui's dolphin

The Maui's dolphin is believed to be a subspecies of the Hector's dolphin and is found off the west coast of the North Island (Maunganui Bluff in Northland to Oakura Beach, Taranaki). Under the Marine Mammals Protection Act 1978, Maui's dolphins are a protected species. They are classified as 'nationally critical' in the NZ threat classification and 'nationally endangered' by the IUCN. The most recent population estimate for the species is 55 individuals (95% confidence intervals of 48 – 69), which is significantly lower than the 2005 estimate of 111 individuals (95% confidence intervals of 48– 252) (Hamner *et al.*, 2012).

Maui's dolphins have a coastal distribution and are generally found in water depths of less than 20 m. Most sightings occur within 4 Nm of the coastline, although they have been sighted up to 7 Nm from the shore (Du Fresne, 2010) and at 19 Nm from the Māui A platform. The latter of the two sightings should be treated with caution as it was a public sighting without photo/video evidence.

Maui's dolphins are thought to range between Maunganui Bluff, Northland and Oakura Beach in Taranaki. Over the last ten years, marine mammal surveys have extended south of Raglan and Kawhia but no Maui's dolphins have been observed (Ferriera and Robers, 2003, Slooten et al., Webster and Edwards, 2008). This lack of sightings could be explained by the fact that these areas lie outside of the core range of the species or that dolphins are resident in the area but are so few that they were simply missed during the surveys conducted in the region (Du Fresne, 2010). There is evidence that Maui's/Hector's dolphins visit the stretch of Taranaki coastline from reports of this species in Port Taranaki in 2007, video footage of a Maui's/Hector's dolphin off the Waiongana Stream in December 2009 and a Maui's/Hector's dolphin caught in a set net near Cape Egmont.

The DOC sighting database has recorded two Maui's dolphin within the NWF Operational Area, whereas the largest distribution of sightings have occurred along the inshore coastal waters centred between Kaipara Harbour to Kawhia Harbour, although they have been observed to the north and south of these harbours. There have been no strandings of Maui's dolphins along the west coast of the North Island that have been recorded on the DOC stranding database.



The NWF 2D MSS is being acquired mostly in water depths greater than 300 m and located beyond the AEI and MMS. However, even though the NWF Operational Area is beyond the core range of most Maui's dolphin sightings, there is still a possibility one could be observed during the NWF 2D MSS. If a Maui's dolphin sighting was made during the NWF 2D MSS, DOC would be notified as soon as possible. If the sighting was reliable, DOC staff may mobilise a boat to try and gather a biopsy sample. The biopsy sample would be used to verify sub-species (Hector's or Maui's dolphin) using genetic (DNA) analysis and would add to the knowledge about the Maui's dolphin and their offshore range. Contact details of DOC staff can be found below:

lan Angus (DOC National Office)

Callum Lilley (Taranaki Area Office)

4.2.4.4.13 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 can grow to 1.7 - 2.4 m in length, weigh 70 - 110 kg and feed on a variety of prey (fish (anchovies), small mid-water fish (jack mackerel) and squid) (Meynier *et al.*, 2008). Sexual maturity in common dolphins is estimated between 7-12 years for males and 6-7 years in females. The oldest animal on record for this species is 29 years old which was determined for a freshly stranded carcass.

Common dolphins are distributed around the entire NZ coastline, generally remaining within a few kilometres of the coast. They are social animals and can 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 and Baker, 1997). The principal predators of common dolphins are killer whales.

The DOC sighting database has records of common dolphins along the entire west coast of the North Island, including within the NWF Operational Area. Likewise the DOC stranding database has recorded common dolphins along the same stretch of coastline inshore of the NWF Operational Area. Therefore it is highly likely that common dolphins will be observed during the NWF 2D MSS.

4.2.4.4.14 Bottlenose Dolphin

Bottlenose dolphins range from $2.4-4\,\mathrm{m}$ in length and $250-650\,\mathrm{kg}$ in weight. Throughout the world, bottlenose dolphins are widely distributed in cold temperate and tropical seas, with NZ being the southernmost point of their range.

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 Marlborough Sounds to Westport region. The subpopulation of Fiordland bottlenose dolphin is listed as critically endangered. 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.

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

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.



The DOC sighting database has two observations within the NWF Operational Area, while there is also one recorded sighting inshore and two to the south. The DOC stranding database has nine records inshore the northern portion of the NWF Operational Area. As a result, there is the potential for bottlenose dolphins to be observed during the NWF 2D MSS; however, given the distance offshore, if sighted it is most likely that they would be the offshore sub-species of bottlenose dolphins.

4.2.4.4.15 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. 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.

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). 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. From necropsies performed it was found that these whales were not from the NZ resident population.

Killer whales have been observed within, inshore, to the south and offshore from the NWF Operational Area following an assessment of the DOC Sighting Database. The DOC stranding database has records of killer whale strandings along the coastline inshore of the NWF Operational Area. As a result, it is likely that killer whales may be encountered during the NWF 2D MSS.

4.2.4.4.16 Pilot Whale

Pilot whales are also a member of the dolphin family; males are larger than females and can grow up to 6 m long and weigh 3 tonnes. There are two species of pilot whales; long-finned and short-finned, of which the long-finned is more likely to be found in NZ waters. Long-finned pilot whales are a migratory species; they prefer cold temperate coastal waters and along shelf breaks, where they feed on fish and squid in deeper water.

Pilot whales are notorious for stranding along the NZ coastline. Strandings generally peak in spring and summer (O'Callaghan, 2001), with Farewell Spit renown for the number of whale strandings each year.

They are very social animals and often travel in groups of over 100 individuals; it was originally thought the family relationships among the pilot whales were the cause of strandings as a result of their 'care-giving' behaviour. The theory was that if one or a few 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 was proven 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).

Pilot whales have been observed within and surrounding the NWF Operational Area from the recorded sightings on the DOC sighting database. The DOC stranding database shows a number of records for pilot whales inshore of the NWF Operational Area. Pilot whales are often observed during seismic surveys within the Taranaki basin and it is highly likely they will be observed during the NWF 2D MSS.



4.2.5 Pinnipeds

Nine species of pinnipeds (seals and sea lions) have been recorded in NZ waters (Suisted and Neale, 2004). Within NZ waters, the NZ fur seal (*Arctocephalus forsteri*) is the most common of the pinnipeds. They are distributed around NZ, with a population estimate of 50,000 – 60,000 but this is likely to be significantly underestimated. 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.

NZ fur seals are known to dive for up to 12 minutes (~ 200 m) to feed on fish (small midwater fish, conger eels, barracouta, jack mackerel and hoki), squid and octopus.

NZ fur seals are present around the entire NZ coast with sighting information covering the extent the country. It is noted that a large proportion of the sighting observations have arisen from previous MSSs around NZ where dedicated MMO's have been onboard. The DOC sighting database has records within the NWF Operational Area; however, most are directly to the south which is probably due to MSS activity. As a result it is highly likely that NZ fur seals will be observed within the NWF Operational Area.

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. As a result, most sightings occur around Northland (DOC, 2014f).

There are records of live and dead specimens, or shed skin of all seven of these species within (or in very close proximity) to the NWF Operational Area (DOC, 2014f). These records are generally coastal in location, but this distribution is probably an indication of higher numbers of potential observers in these areas rather than an accurate representation of these animals distribution in NZ waters. As a result, these reptiles may well be observed within the NWF Operational Area and if observed will be recorded and will further increase the knowledge of NZ's marine reptiles.

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 (Far 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, Pierce and Parrish, 1993, Powlesland, 1990, IUCN, 2014, Robertson et al., 2012) have been used to identify the seabirds most likely to be observed in and around the NWF Operational Area and their conservation status. The list is as follows:

Snowy wandering albatross (Diornedea exulans) – common visitor to NZ waters; vessel follower; IUCN "vulnerable" status; NWF Operational Area within "species normal range"; DOC conservation status "non-resident native, migrant, threatened overseas";



- Gibson's wandering albatross (Diomedea gibsoni) uncommon endemic; vessel follower; not yet assessed by IUCN; NWF 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; NWF Operational Area within "species normal range"; DOC conservation status "threatened, island endemic, recruitment failure, range restricted";
- Southern royal albatross (Diomedea epomophora) locally common endemic; IUCN "vulnerable" status; NWF Operational Area within "species normal range" and including a hotspot for the species west of Taranaki; DOC conservation status "at risk, naturally uncommon, range restricted";
- Northern royal albatross (Diomedea sanfordi) locally common endemic; IUCN "endangered" status; NWF 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; NWF Operational Area within "species normal range"; 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; NWF Operational Area within "species full 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; NWF Operational Area within "species normal range"; DOC conservation status "at risk, declining, extreme fluctuations, range restricted";
- Salvin's mollymawk (*Thalassarche salvini*) locally common endemic; keen vessel follower; IUCN "vulnerable" status; NWF Operational Area within "species normal range"; DOC conservation status "threatened, nationally critical, range restricted";
- **Grey-headed mollymawk** (*Thalassarche chrysostoma*) locally common native; gathers around stationary boats; IUCN "endangered" status; NWF 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;
 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; NWF Operational Area within "normal species offshore range" and including coastal hotspots; "range restricted"; DOC conservation status "threatened, nationally vulnerable, threatened overseas":
- Buller's shearwater (*Puffinus bulleri*) common endemic; migrates to America during the winter: IUCN "vulnerable" status; NWF Operational Area within "species normal range"



- and including a hotspot on the tip of Northland and off the northwest coast of NZ; 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; NWF Operational Area within the "species normal range" and including a hotspot off Northland; DOC conservation status "at risk, declining, secure overseas";
- Short-tailed shearwater (Puffinus tenuirostris) locally common migrant; migrates to the
 northern pacific in the winter; passes through NZ waters during spring and autumn
 migrations; not yet assessed by IUCN; DOC conservation status "non-resident native,
 migrant, secure overseas";
- Fluttering shearwater (Puffinus gavial) abundant endemic; ranges offshore in the winter; not yet assessed by IUCN; DOC conservation status "at risk, relict, range restricted":
- Little shearwater (Puffinus assimilis) locally common native; IUCN "least concern" status; DOC conservation status "non-resident native, vagrant, secure overseas";
- Common diving-petrel (Pelecanoides urinatrix) abundant native; IUCN "least concern" status; DOC conservation status "not threatened, designated, range restricted, secure overseas":
- Black petrel (Procellaria parkinsoni) rare endemic; IUCN "vulnerable" status; NWF Operational Area within species normal range including a hotspot north of Northland; DOC conservation status "threatened, nationally vulnerable, range restricted";
- Snares cape pigeon (Daption capense) common native; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, range restricted"
- Southern giant petrel (Macronectes giganteus) common visitor; IUCN "least concern" status; NWF Operational Area within the "species full range"; DOC conservation status "non-resident native, migrant, secure overseas";
- Northern giant petrel (Macronectes halli) common native; IUCN "least concern" status; NWF 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"
- Antarctic prion (Pachyptila desolata) locally common native; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, range restricted, secure overseas";
- Black-winged petrel (Pterodroma nigripennis) locally common native; IUCN "least concern" status; DOC conservation status "not threatened, designated, increasing, range restricted";
- **Kermadec petrel** (*Pterodroma neglecta*) locally common native; IUCN "least concern" status; NWF Operational Area within the "species full range"; DOC conservation status "at risk, relict, secure overseas":
- Grey-faced petrel (Pterodroma macroptera) common native; IUCN "least concern" status; NWF Operational Area within "species full range" and including a coastal hotspot; DOC conservation status "not threatened, designated, increasing, range restricted";
- 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 "non-resident native, vagrant, secure overseas";
- Blue penguin (Eudyptula minor) common native; IUCN "least concern" status; DOC conservation status "at risk, data poor, extreme fluctuations";



- Red-tailed tropicbird (Phaethon rubricauda) rare vagrant; occasionally seen off Northland; IUCN "least concern" status; DOC conservation status "nationally endangered, range restricted, secure overseas, stable";
- 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";
- **Brown booby** (Sula leucogaster) rare vagrant to waters to the north of NZ; IUCN "least concern" status; DOC conservation status "non-resident native, vagrant, secure overseas":
- Masked booby (Sula dactylatra) uncommon native; occurs in seas north of Taranaki;
 IUCN "least concern" status; DOC conservation status "threatened, nationally endangered, range restricted, stable, threatened 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; seen in coastal northland;
 IUCN "least concern" status; DOC conservation status "threatened, nationally vulnerable";
- Little black shag (Phalacrocorax sulcirostris) locally common native; seen in lakes and sheltered coastal waters in northland; IUCN "least concern" status; DOC conservation status "at risk, naturally uncommon, range restricted";
- Little shag (Phalacrocorax melanoleucos) common native; IUCN "least concern" status; DOC conservation status "not threatened, increasing";
- Spotted shag (Phalacrocorax punctatus) locally common native; occurs off Auckland west coast; IUCN "least concern" status; DOC conservation status "not threatened";
- 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; IUCN "endangered" status; NWF
 Operational Area within "normal coastal species range" from mid-Taranaki to north of
 Kaipara and full range north of that; "recruitment failure"; DOC conservation status
 "threatened, nationally critical";
- 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; normal species range around Kaipara harbour; DOC conservation status "threatened, nationally endangered, recruitment failure, sparse";
- Caspian tern (Hydroprogne caspia) reasonably common native; occurs in sheltered
 coastal waters, harbours and estuaries; species not yet assessed by IUCN; NWF
 Operational Area is within the "normal coastal species range" and includes hotspots
 located around the harbours of the west coast and the tip of northland; DOC conservation
 status "threatened, nationally vulnerable, 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";
- Fairy tern (Sterna nereis) rare native; IUCN "vulnerable" status; "threatened, nationally critical, conservation dependant, range restricted";
- Little tern (Sterna albifrons) uncommon Asian migrant; occurs in Kaipara and Manukau harbours; IUCN "least concern" status; DOC conservation status "non-resident native, migrant, secure overseas";
- Common noddy (Anous stolidus) rare native at Kermadec Islands; IUCN "least concern" status; NWF Operational Area is within "species normal range"; DOC conservation status "non-resident native, coloniser, one location, secure overseas"; and
- White tern (Anous tenuirostris) rare native; IUCN "least concern" status; NWF Operational Area within "species normal range"; DOC conservation status "threatened, 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 in coastline bordering the NWF Operational Area (MPI, 2014d, Parkinson, 2006, Pierce and Parrish, 1993, Powlesland, 1990, Brooks et al., 2011, NZ Birds online, 2014, Auckland Regional Council (ARC), 2013, DOC, 1999, Gill et al., 2010). These species are listed below and the locations of the main breeding areas for all species are displayed on the map in Figure 32.

- Australasian gannet (Morus serrator) breeding season: August to March;
- Black shag (Phalacrocorax carbo) breeding season: year round;
- Black-winged petrel (Pterodroma nigripennis) breeding season: October to May:
- Blue penguin (Eudyptula minor) breeding season: July to February;
- Buller's mollymawk (Thalassarche bulleri) breeding season: October to June:
- Caspian tern (Hydroprogne caspia) breeding season: September to January;
- Common diving petrel (Pelecanoides urinatrix) breeding season: August to December:
- Fairy tern (Stema nereis) breeding season: October to February:
- Flesh-footed shearwater (Puffinus cameipes) breeding season: September to May;
- Fluttering shearwater (Puffinus gavial) breeding season: August to January;
- Grey-faced petrel (Pterodroma macroptera) breeding season: March to January;
- Little black shag (Phalacrocorax sulcirostris) breeding season: October to December:
- Little shag (Phalacrocorax melanoleucos) breeding season: August to March;
- Little shearwater (Puffinus assimilis) breeding season: April to November;
- Pied shag (Phalacrocorax varius) breeding season: year round;
- Red-billed gull (Larus novaehollandiae) breeding season: September to January;
- Sooty shearwater (Puffinus griseus) breeding season: November to May;
- Spotted shag (Phalacrocorax punctatus) breeding season: year-round;
- Black-backed gull (Larus dominicanus) breeding season: September to March;
- White-faced storm petrel (Pelagodroma marina) breeding season: October to April;
- White-fronted tern (Sterna striata) breeding season: October to January; and
- Black-billed gull (Larus bulleri) breeding season: August to March.



It should be noted that a number of coastal and estuarine bird species also breed along the coast adjacent to the NWF Operational Area (NZ Birds online, 2014, Auckland Regional Council (ARC), 2013, DOC, 1999). These include the "nationally critical" grey duck (Anas superciliosa); "nationally endangered" Australasian bittern (Botaurus poiciloptilus) and reef heron (Egreta sacra); and the "nationally vulnerable" blue duck (Hymenolaimus malacorynchus), NZ dotterel (Charadrius obscurus) and banded dotterel (Charadrius bicinctus) (Robertson et al., 2013).





Figure 32: Seabird breeding areas in close proximity to the NWF Operational Area.



4.3 Coastal and marine conservation

4.3.1 Regional Coastal Environment

The NWF Operational Area extends over a large section of the west coast of the North Island of NZ. Inshore of the NWF Operational Area within the Coastal Marine Area (CMA) is the responsibility of Northland Regional Council, Auckland Regional Council, Waikato Regional Council and Taranaki Regional Council (Figure 33). 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 NWF Operational Area. In addition to the areas of significance listed in the sections below, the WCNI MSS extends over a large portion of coastal waters inshore of the NWF Operational Area. The WCNI MSS is covered in more detail in Section 2.4.

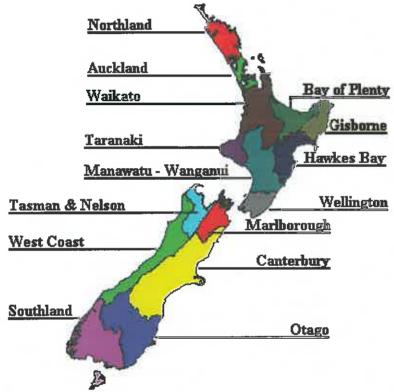


Figure 33: Regional and District Council Boundaries

4.3.1.1 Northland Coastline

The following sites were defined as Priority Areas by DOC (DOC, 1999) and frequently overlap with Areas of Significant Conservation Value (ASCV) defined for the Northland region (Figure 34). As a result, the vast majority of Northland ASCV's are included within a Priority Area and a summary is provided below:

- Te Paki/Parengarenga area covers the northern section of Muriwhenau (Aupouri Peninsula) includes steep coastal cliffs, extensive dune lands (Ninety-mile beach) and wetlands harbouring endemic and threatened flora and fauna. Te Rerenga Wairua (Cape Reinga) is a site of great significance to all Māori and comprises over 1,000 recorded archaeological sites. Other noteworthy historical features include the lighthouses at Cape Reinga and on Motuopao Island and the relics of whaling stations and gum-diggings.
- Pouto/Kaipara area includes the northern section of Kaipara Harbour. It is a nationally and internationally important roosting and breeding site for coastal and estuarine wading birds (including godwits and NZ dotterel). The site encompasses a variety of different habitats: sheltered estuaries, saltmarshes, salt meadows, mangroves, tidal flats and a

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dynamic harbour mouth. The Pouto Peninsula is a unique dune system particularly recognised as the habitat of dwarf inanga and *Hydatella*. Ngati Whatua view the entire west coast as waahi tapu because of the large number of koiwi buried there.

- Hokianga Harbour/Puketi contains a range of different habitat types: mangroves, saltmarsh, tidal mudflats and large sand dunes. As a result, this area is highly valuable to numerous coastal and wading birds including threatened and endemic species.
- Ahipara Plateau extends from the south of Ninety-Mile Beach to the mouth the Herekinoa Harbour. The coastline is mainly covered in large mobile dunes except at Tauroa Point which features rocky reefs. The area include numerous archaeological sites including pa, terraces and middens.
- Three Kings Islands Nature Reserve serves as refuge for threatened species and hold high numbers of endemic plants and animals. They also have numerous archaeological and more recent historical sites such as lighthouses.

Northland Regional Council (NRC) defined the following areas as Marine 1 (Protection) Management Areas in the Northland Regional Coastal Plan (Northland Regional Council (NRC), 2004).

- Twilight Beach to Ohao Point is valued for its protected areas, marine mammals, ecosystems, habitats and geological values. It includes sub-tidal habitats which support unique marine ecosystems and species. In addition, the inter-tidal areas provide significant habitat for wading birds including threatened species.
- Kawerua Coast includes protected areas, coastal wetlands, marine mammals, birds and ecosystems. The inter-tidal areas provide habitat for NZ endemic wading birds including threatened species. The area also contains the greatest diversity of inter-tidal and shallow sub-tidal rocky reef habitats in western Northland.

The Northland Regional Coastal Plan (Northland Regional Council (NRC), 2004) defines "all parts of the coastal marine area which are not either Marine 1 (Protection), Marine 3 (Marine Farming), Marine 4 (Mooring), Marine 5 (Port Facilities) or Marine 6 (Wharves) Management Areas as Marine 2 (Conservation) Management Areas and without precluding the provision for appropriate subdivision, use and development to manage those remaining areas in such a way as to protect, and where practicable, enhance natural, cultural and amenity values".

4.3.1.2 Auckland Coastline

Auckland Regional Council (ARC) defined areas of ASCV and Significant Ecological Areas (SEA) in Annexe 2 of the Auckland Unitary Plan (Schedule of Significant Ecological Areas – Marine) (Auckland Regional Council (ARC), 2013) (Figure 34). In addition to being listed as SEAs, some of these are also categorised as ASCVs and are summarised below:

- Port Albert contains mangroves and intertidal banks which provide a habitat and feeding ground for wading birds.
- Tapora Islands and Estuary includes intertidal areas (sandbanks, bars and dunes) and
 islands which provide feeding grounds, and mid- and high-tide roost for international
 migratory and NZ endemic wading and coastal birds, including threatened species. Other
 habitats in the area include mangrove, saltmarsh and estuarine wetlands which all host a
 diverse range of plants and birds including threatened species.
- Tauhoa River has intertidal banks flanked by mangroves which support saltmarsh and intertidal fauna. Saline vegetation along the riverbank also provides shelter and nesting sites for coastal fringe birds. The Tauhoa Scientific Reserve has been selected as an ASCV.
- Moturemu Island supports a breeding colony of grey-faced petrel and a number of regionally and nationally threatened plant species.



- Kaipara Harbour's sea grass meadows support a wide variety of fish and the harbour is the main source of juvenile snapper for the west coast of the North Island.
- **Mataia** contains a rare type of gradation from mangrove to kanuka forest. The area also provides feeding habitat for waders.
- Jordan's farm, Oyster Point and Shelly Beach Island include intertidal banks, shell
 banks and mangroves which provide feeding ground, roosting sites and nesting sites for
 international migratory and NZ endemic wading birds, including a number of threatened
 species. Shelly Beach Island provides the numerically most important high tide roost on
 the Kaipara for a variety of coastal birds including the Caspian tern (threatened species).
 Saline vegetation on the Island also provides habitat for the coastal fringe birds. Shelly
 Beach Island has been selected as an ASCV.
- Kaipara River Mouth contains extensive mangroves which grade into areas of saltmarshes and then terrestrial vegetation on the highest ground. These provide shelter and nesting sites for coastal fringe birds.
- Puharekeke has intertidal banks fringed with mangroves and shell banks which provide
 habitat (including key roosting and nesting sites and extensive intertidal feeding habitat)
 for coastal fringe birds and waders.
- Omokoiti has saltmarsh and mangrove vegetation, and intertidal banks which provide a
 feeding ground and roosting site for thousands of international migratory and NZ endemic
 wading and coastal birds, including a number of threatened species (e.g. black stilts).
- South Kaipara Head Waionui Inlet is an estuarine ecosystem including areas of mangroves and salt marches which grade to manuka-kanuka forests, dune land and seasonal wetland, which all provide habitat for a variety of threatened plants and large numbers of wading and coastal fringe birds, including threatened species. Papakanui Spit is used as a high tide roost for international migratory and endemic wading birds, including threatened species. It is one of the largest nesting sites for white-fronted terns and a major breeding site for wading birds, including NZ dotterels, variable oystercatchers and NZ fairy terns. South Kaipara head also includes large mobile dune fields which include extensive areas of pingao-spinifex as well as kanuka which are very rare in NZ and of high priority for biodiversity protection. South Kaipara Head is also an ASCV.
- Oaia Island supports a breeding colony of Australasian gannet and is used as a haulout for NZ fur seals. Cook's scurvy grass (nationally threatened) has also been recorded there.
- Muriwai has an exposed sandy beach which supports bivalves including toheroa.
- West Coast (Muriwai to Karekare) includes rocky shores and reefs supporting marine algae and invertebrates, including bull kelp (marine algae of cooler waters) in significant quantities. The coast also provides habitat for cliff-dwelling plants. Coastal and sea birds breed on the cliffs and feed in the surrounding waters. Large sandy beaches provide habitat for animals and plants including pingao. The Muriwai gannet colony is the northernmost mainland breeding colony for the species. Erangi Point is the site of a breeding colony of spotted shag (endemic species). Kauwahaia Island has a high diversity of bird species including breeding grey-faced petrel, sooty shearwater, diving petrel, flesh-footed shearwater. Ihumoana Island is host to a remnant grey-faced petrol colony. Grey-faced petrel also nest on the cliff top south of Piha and above Union Bay at Karekare. Blue penguin also nest along the coastline. The coastline from Paikea Bay to Anawhata Beach also contains high levels of intertidal biodiversity. This area is classified as an ASCV.
- Whatipu has mobile dunes which present the best example of progradation in NZ and are considered to be a nationally important landform. The area hosts high numbers of threatened bird species which roost in the dunes and feed in the surrounding waters. White-fronted terms nest in the area. The vegetation includes pingao and spinifex communities and is considered amongst the best in the Waitakere ecological district.



- Omanawanui has strong, cool currents and erosion-resistant rock and supports a high level of marine biodiversity including encrusting fauna which is rare elsewhere in the North Island, sheltered harbour species, low tidal nudibranchs. This area is an internationally important wetland which has been selected in its entirety as an ASCV.
- Huia to Cornwallis supports a combination of marine habitats. Huia Bay is an important bird feeding area for a number of species including reef herons (nationally vulnerable). From Cornwallis wharf to the southeast of Kakamatua Inlet, high biodiversity values are also observed. This area includes the richest intertidal sponge gardens around the Waitakere coast (14 species of sponge) which host two species of rare Calliostoma snail.
- Big Muddy Creek is an area of intertidal flats which support soft shore fauna and
 Zostera beds which grade to algal beds and mangrove. Coastal fringe birds feed in the
 intertidal zone and roost in the saline vegetation. Lawry Point includes populations of rare
 ranellid trumpet shells, nudibranchs, and the tube worm Spirobranchus cariniferus, and
 possibly the richest sea squirt habitat in the North Manukau coast.
- Little Muddy Creek is an estuarine inlet which contains a range of intertidal habitats, from algal beds to mangrove marsh and coastal forest.
- Cape Horn provides feeding grounds for waders and coastal birds. Pied shags (nationally vulnerable) and little shags (naturally uncommon) are also know to roost in the coastal forest and kaka have been recorded in the area.
- Green Bay Coastline has sea cliffs with coastal forest which provide roosting for pied shags and little shags.
- Ann's Creek comprises ecological sequences from saltmarsh to freshwater wetland and mangroves which provide habitat for wading birds.
- Southeast Mangere Inlet is an intertidal area which supports a range of native saline vegetation.
- Ambury presents intertidal flats and banks which are a feeding ground for thousands of
 international migratory and NZ endemic wading and coastal bird species, including a
 number of threatened species. Amongst other things, it is an important winter roost for
 the South Island pied oystercatchers. Other species which use the area include the whitefaced heron, banded rail, shoveler duck, pied stilt, royal spoonbill, NZ dotterel, blackbacked gull, welcome swallow, wrybill, banded dotterel, eastern bar-tailed godwit, lesser
 knot, turnstone, curlew sandpiper, golden plover, dabchick, paradise duck, little egret and
 black-fronted dotterel. Rare visitors include the black-fronted tern, black tern, black stilt,
 black-billed gull and the occasional NZ fur seal.
- Mangere Lagoon is an important feeding ground for wrybills.
- Te Tau Bank East is a sandbank containing large numbers of shellfish and providing a feeding area for wading birds.
- Puke Tutu Island and its intertidal areas are used as a high tide roost and feeding habitat by a range of wading birds species, including threatened species.
- Ihumatao includes the Karore intertidal sandbank which includes one of the most extensive areas of eelgrass beds (*Zostera*) in the Manukau Harbour. Fish, wading birds and waterfowl feed on the bank and around the eelgrass beds. The Otuataua Stonefields historic reserve and waahi tapu site lie inland of this area. Additionally, Otuataua is significant for wading birds. It combines sand flat habitats with the most extensive eelgrass area in Manukau Harbour. Fish, wading birds and waterfowl feed on the Karore Bank.
- Pahurehure Coastline provides extensive areas of feeding habitat for waders.
- Puhinui is comprised of intertidal banks and shell banks which host intertidal sand flat organisms and provide feeding grounds for thousands of international migratory and NZ endemic wading birds, including a number of threatened species (banded rail, fernbird,



marsh crake). Puhinui Creek holds some of the oldest mangroves in the harbour which are, in places, fringed by bachelor's button meadows. An artificial roost has been constructed at Wiroa Island which is widely used by coastal birds and waders.

- **Drury** contains a range of intertidal habitats (sandy mud intertidal flats, rocky reefs, saline vegetation). Mangroves and eelgrass beds also exist in the area. Wading birds including the pied stilt roost in the area.
- Clarks Beach to Karaka Point includes intertidal banks and shell banks which host the greatest diversity of intertidal sand flat organisms in the Manukau Harbour and provide feeding and roosting grounds for thousands of international migratory and NZ endemic wading birds, including a number of threatened species. Eel grass beds cover an extensive area between Clarks Beach and Seagrove and the area has selected the intertidal bank as an ASCV.
- Taihiki River supports habitats which range from sandy intertidal flats to mangroves and pockets of saltmarsh. It is an important nursery area for young flounder and grey mullet. It also provides feeding and roosting habitat to wading birds including the banded rail.
- Waipipi has intertidal flats, shells and sand banks which provide roosting habitat for international migratory and NZ endemic waders and coastal birds. Saltmarsh and mangroves which flank the tidal creeks provide habitat to banded rail. This area was selected as an ASCV.
- Waiuku provides feeding habitat for waders.
- Pollock Spit includes sandbanks with adjoining mangroves. The banks are used as
 roosting for thousands of international migratory and NZ endemic wading and coastal
 birds, including a number of threatened species. The area was selected as an ASCV.
- Awhitu has shoreline habitats which are used by wading and coastal birds for feeding.
 Moreover, saline vegetation supports coastal fringe and wetland birds. This area also
 contains intact sequences from shoreline habitat to mangrove, estuarine and freshwater
 wetlands. Banded rail and north Island fern bird inhabit the wetlands and coastal margins.
 This area was selected as an ASCV.
- Awhitu South Head to Big Bay –supports rich marine fauna similar to at Omanawanui on the opposite side of the harbour mouth.

4.3.1.3 Waikato Coastline

Waikato Regional Council has identified the following sites below as ASCVs within the Waikato Regional Coastal Plan (Waikato Regional Council, 2014) and are displayed in Figure 34. The sites are identified based on the presence of Māori cultural values of local, regional or national significance; the presence of protected areas; wetlands estuaries and coastal lagoons or national or international significance; habitats, breeding sites, roost sites or feeding sites of marine mammals and birds; ecosystems, flora and fauna habitats with regionally, nationally or internationally significant or threatened ecosystems or species; scenic sites of regional, national or international importance; historic places of outstanding significance; representative examples of nationally significant or outstanding coastal landforms and associated processes.

A summary of the ASCVs along this coastline is listed below:

- Mokau River Estuary is a site of cultural importance to Taranaki and Tainui iwi.
 Furthermore, it is a regionally important site for whitebait (spawning habitat) and native
 fishery. Rare and threatened wildlife are resident or are known to occur in the estuary's
 waters (waders and coastal birds). The coastal features in this area have also been
 identified as valuable.
- Marokopa River Estuary is of cultural importance to Tainui iwi for kaimoana gathering. Rare and threatened wildlife is resident or is known to occur in the estuary's waters



(waders and coastal birds, Hector's/Maui's dolphin). Important geopreservation sites (Marokopa zeolite facies, Marokopa-Kiritehere coast, Marokopa River mouth Triassic-Jurassic contact) have also been identified.

- Albatross Point and adjoining coastline NZ fur seals are known to haul out in the area. The site is also significant from a geological perspective (fossils). Arataura Point and Ururoa Point are of particular significance.
- Kawhia Harbour is a valuable site to the Tainui iwi which is referred to as the "Hearth of Tainui". It also encompasses a canoe resting site Te Ahurei. The harbour is an outstanding habitat for wildlife including endangered rare and threatened wading and coastal bird species. It possesses extensive eel grass communities and Hector's/Maui's dolphin are also know to occur in its waters. Other sites of note include fossil sites (Te Maika Point, Totara Point, Arataura Point, Heteri Point, Ohaua Point, Ururoa Point, Puti Point, Motutara Peninsula), Waiharakeke bridge kinohaku Jurassic sequence, Maire point, the historic pohutukawa tree, and Te Puia Springs.
 - Kawhia Harbour has been described as a 'seafood basket' of Tainui, because of the richness of the kaimoana. To help protect the rich kaimoana found at Kawhia, a Taiapure was established in 2000 which covers Kawhia Harbour out to 2 Nm. A Taiapure gives special status (under the Fisheries Act 1996) to a coastal/estuarine area of customary significance, where management, but not control, is vested in the local hapu or iwi.
- Aotea Harbour is a site of cultural importance to Tainui iwi. The harbour adjoins a sandspit and dune system which is classified as Scientific Reserve. The site contains extensive eel grass communities which forms a significant vegetation community in the harbour as well as being the base of the food chain for herbivores. Aotea Harbour is relatively sandy as a result of having the majority of the freshwater wetlands remaining intact. These wetlands provide an important filter between the land and the harbour and provide significant habitat for wetland birds such as Fernbird. Rare and threatened waders and coastal birds are resident or occur in its waters as well as Hector's/Maui's dolphins which can be sighted in the area. From a geological perspective, the site contains a nationally significant dune complex of Titanomagnetic iron sand and two geopreservation sites (Aotea dune fields and Taranaki Point).

The Aotea Harbour is a site of cultural importance as it was the landing place of the Aotea waka, which brought the ancestors of the Ngã Rauru and Ngãti Ruanui tribes to New Zealand. When they discovered the Tainui people in occupation, they travelled south to Taranaki.

- Gannet Island consists of the eroded remnant of a 'tuff ring', and erupted about half a million years ago. It is located on the eastern edge of the North Taranaki Graben, rising 15 m above sea level from a base about 65 m deep. Gannet Island is protected as a wildlife sanctuary as it is New Zealand's largest single breeding colony of Australasian Gannets, holding in excess of 20,000 breeding birds through November to February. Gannet Island also provides a haul out area and breeding site for NZ fur seals.
- Raglan Harbour runs 12 km inland from the entrance and is a site of cultural significance to Tainui iwi. Numerous rare and threatened wading and coastal birds reside or frequent the area. The Raglan area has been inhabited for at least 800 years and was originally known by Maori as Whangaroa 'the long pursuit'. To avoid confusion with another place of the same name, Whaingaroa was later adopted. Raglan harbour has resident and frequenting rare and threatened wading and coastal fauna, and is also known to have sightings of Hector's/Maui's dolphin. Raglan is also recognised as the southern limit of the mangroves.
- Waikato River mouth and estuary is of immense value to Tainui iwi. It is a wildlife
 habitat of high value and a nationally significant whitebait and native fishery. Rare and
 threatened waders and coastal birds are known to reside in or frequent the area. In
 addition, the site is recognised as nationally significant for fossil and exposed land forms



and comprises two geopreservation sites (Port Waikato complex landslide and Port Waikato).

4.3.1.4 Taranaki Coastline

The Taranaki Regional Coastal Plan (Taranaki Regional Council (TRC), 1997) defines a number of areas within the CMA with significant conservation values that have policies in place to protect them from any adverse effects of use or development. The significant areas of relevance within the Taranaki region to the NWF Operational Area are shown in Figure 34 and discussed further below.

- Sugar Loaf Islands Marine Protected Area (SLIMPA)- is the remnants of an old volcano formed 1.75 million years ago that has eroded away leaving a group of low sea stacks and seven islands providing a unique semi-sheltered environment with a diverse range of underwater habitats and marine life, along an otherwise exposed coastline (DOC, 2014d). A diverse range of subtidal marine habitats provides habitat for at least 89 species of fish, 33 species of encrusting sponges, 28 species of bryozoans and 9 nudibranchs (DOC, 2014d). SLIMPA is predator free and there are 19 species of seabirds found on and around the island, with ~10,000 seabirds nesting there each year. The NZ fur seal also use SLIMPA as breeding grounds.
- Tapuae Marine Reserve covers 1,404 ha and has a diverse range of habitats including canyons and boulder fields; providing a safe haven and nursery for a wealth of underwater marine life (DOC, 2014e). It adjoins SLIMPA and extends south to Tapuae Stream and has a contrast of marine environments within the reserve. To the northwest of the reserve are islands, remnants of an ancient volcano with caves, canyons, boulder fields, while to the southwest it is less sheltered and is a classic example of the wild Taranaki coastline (DOC, 2014i). A diverse range of fish, invertebrate and algal species live in the reserve and is an important breeding and haul out area for NZ fur seals.



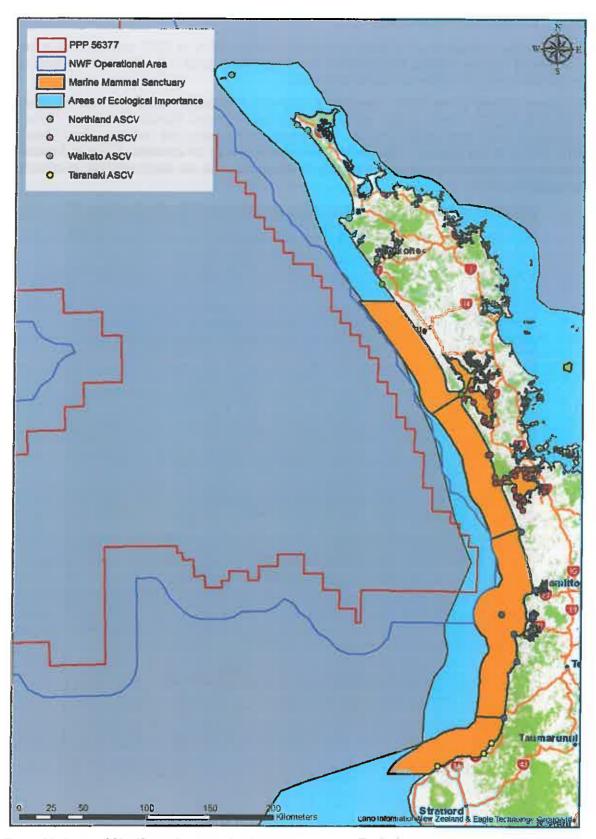


Figure 34: Areas of Significant Conservation Value and Areas of Ecological Importance



4.3.2 Benthic Protection Areas

The Government established 17 Benthic Protection Areas (BPA) in 2007; closing large areas of seabed to bottom trawling and shellfish dredging. As a result 1.2 million km² of seabed was protected which equates to ~32% of the EEZ.

The areas closest to the NWF Operational Area are Challenger North and Norfolk Deep BPA's (Figure 35). These areas are covered by the Fisheries (Benthic Protection Areas) Regulations 2007 and prohibit the use of dredges in the area and limit the use of trawls within 100 m of the seabed. Mid-water trawls are permitted on condition that two fisheries observers are on-board and that the gear is equipped with an electronic net monitoring system (MPI, 2007).

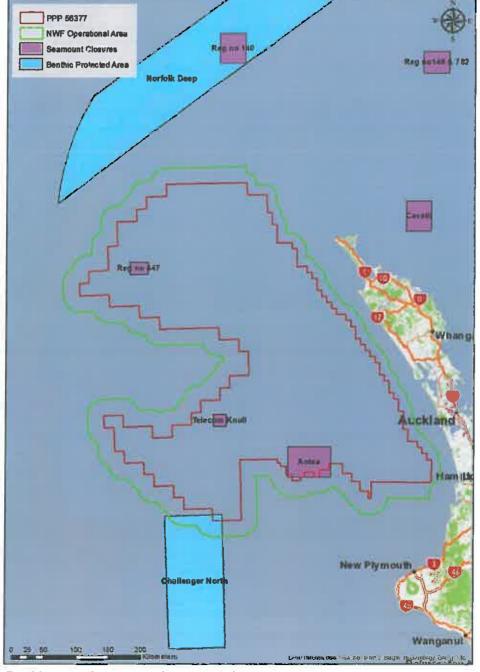


Figure 35: Benthic protection areas and seamount closures



4.3.3 Seamount Closures

In 2001 the government prohibited trawling in 17 seamounts distributed throughout the EEZ. Within these areas all trawling is prohibited and there is no provision for mid-water trawling. Four of the 17 seamount closures are located in or near the NWF Operational Area (Figure 35). These are Aotea Seamount, Seamount 447, Telecom Seamount and Seamount 140.

4.3.4 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 NZ's Territorial Sea and EEZ to provide a spatial framework for structured and systematic management, where geographic domains are divided into units that have similar environmental and biological characters (MfE, 2005).

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 NWF Operational Area falls within NZMEC groups 22, 55, 58, 60, 63 and 64 representing the moderately shallow waters on the continental shelf out to deep water (Figure 36), and are described below following the categories defined by NIWA (MfE, 2005).

- Class 22: is extensive in moderately deep waters (mean = 1,879 m) and is typified by cooler winter SST. Chlorophyll-α only reaches low average concentrations, with characteristic fish species being orange roughy, Baxter's lantern dogfish, Johnson's cod and hoki.
- Class 55: is of restricted extent, occurring at moderately shallow depths (mean = 224 m) around northern NZ and has high annual solar radiation and moderately high winter SST. Average chlorophyll-α concentration is moderate. Characteristic fish species include sea perch, red gurnard, snapper and ling, while arrow squid are also common. The most commonly represented benthic invertebrate families are Dentallidae, Nuculanidae, Pectinidae, Carditidae, Laganidae and Cardiidae.
- Class 58: is of relatively restricted extent occurring in moderately shallow waters (mean = 117 m) around the northern tip of the North Island and in Cook Strait. Strong tidal currents are the dominant feature of this class. Some of the most commonly occurring fish species are red gurnard, snapper, leather jacket, spiny dogfish, barracouta, hoki and eagle ray, while arrow squid are also frequently caught in trawls. The most commonly represented benthic invertebrate families are Veneridae, Carditidae and Pectinidae.
- Class 60: occupies moderately shallow waters (mean = 112 m) on the continental shelf. It experiences moderate annual solar radiation and wintertime SST and has moderately high average chlorophyll-α concentration. Some of the most commonly occurring fish species are barracouta, red gurnard, John Dory, spiny dogfish, snapper and sea perch, while arrow squid are also frequently caught in trawls. The most commonly represented benthic invertebrate families are Dentaliidae, Cardiidae, Carditidae, Nuculanidae, Amphiuridae, Pectinidae and Veneridae.
- Class 63: is extensive on the continental shelf including much of the Challenger Plateau and the Chatham Rise. Waters are of moderate depth (mean = 754 m) and have moderate annual radiation and wintertime SST. Average chlorophyll-α concentration is also moderate. Characteristic fish species include orange roughy, Johnson's cod, Baxter's lantern dogfish, hoki, smooth oreo and javelin fish. The most commonly represented benthic invertebrate familes are Carditidae, Pectinidae, Dentaliidae, Veneridae, Cardiidae, Serpulidae and Limidae.
- Class 64: occupies a similar geographic range to the previous class but occurs in shallower waters (mean = 38 m). Seabed slopes are low but orbital velocities are moderately high and the annual amplitude of SST is high. Chlorophyll-α reaches its



highest average concentrations in this class. Some of the most commonly occurring fish species are red gurnard, snapper, John Dory, trevally, leather jacket, barracouta and spiny dogfish. Arrow squid are also frequently caught in trawls. The most commonly represented benthic invertebrate families are Veneridae, Mactridae and Tellinidae.

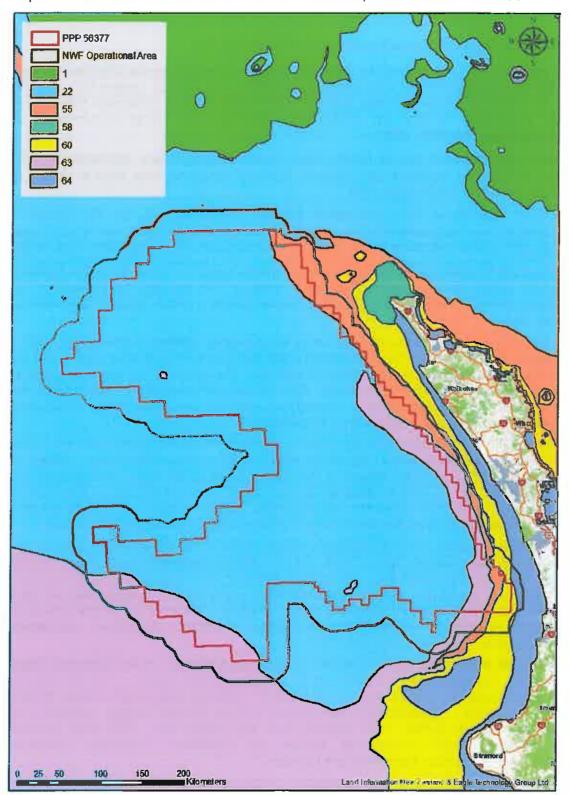


Figure 36: The NZMEC at the 20-class level



4.3.5 Protected Natural Areas

Protected Natural Area's (PNA) are put in place for biodiversity conservation and receive protection as a result of their recognised natural ecological values. Inshore of the NWF Operational Area is the West Coast North Island Marine Mammal Sanctuary, Parininihi and Tapuae marine reserves (Figure 37).



Figure 37: Protected Natural Areas and Marine Mammal Sanctuaries in New Zealand

4.3.6 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.

The sections below provide a brief overview of sites of waahi tapu and taonga along the stretch of coastline inshore of the NWF Operational Area. However, the list of mentioned sites is far from extensive.

4.3.6.1 Northland (Te Tai-Tokerau)

The western coast of the Northland peninsula is subdivided into three rohe moana: Te Apōuri rohe moana, Te Rarawa rohe moana and Ngā Puhi rohe moana.

Northland's Cape Reinga (Te Rerenga Wairua) and its steep headland hold a particularly important place in Māori tradition. After death, spirits of the departed are believed to travel up the west coast of New Zealand by sea until a few miles south of the Cape Van Diemen. They then continue across to the western end of Spirits Bay up to an 800 year-old pohutakawa tree which grows on Cape Reinga. The tree's roots serve as a guide for the spirits as they enter the sea below. Resurfacing at Manawatawi (Great King Island), the spirits take a final glimpse of Aotearoa before returning to the depths and continuing to the other world (Te Aupouri and the Crown, 2012, Te Ara, 2014a).

The tip of the Northland peninsula is said to have been discovered by Kupe who named many places in the region including Te Rerenga Wairua and Te Ara Wairua (the spirits pathway). The area is steeped in history including numerous archaeological sites from the early Māori settlers.

South of Cape Reinga on the west coast, lies Ninety Mile Beach (Te Oneroa a Tohe). The beach is cited as an important natural resource in the Te Rarawa Historical Overview Report (2004) with an intertidal zone hosting many fish and crustacean species, and a complex dune system which provides habitat for many bird species (see <u>Section 4.3.1.1</u>).

Many battles between Te Apōuri and Te Rarawa took place along the beach which was "an important source of political, social, economic and spiritual authority". Today, Te Oneroa a Tohe and its numerous important archaeological sites and links to Ara Wairua is deemed of national importance (Te Uira Associates, 2004).

Whangape and Herekino Harbours were also both the sites of several battles between tribal groups. Whangape Harbour saw the Te Ikaui and Whēru burn their possessions thus creating a smoke screen which hid their escape route across the harbour, giving them the name Te Aupouri (au - current; pour - smoke) (Te Ara, 2014b).

Hokianga Harbour (Hokinanga-nui-a-Kupe – the final departure place of Kupe), within Ngā Puhi rohe, holds a prominent place in Māori history (Te Ara, 2014c). Kupe is said to have settled there in approximatively 925 AD (Wikipedia, 2014). Besides its historical features, the harbour provides traditional food-gathering grounds.

These central historical events and early Māori settlements have all led to the presence of numerous washi tapu, sites of significance and traditional food-gathering grounds within the area (see <u>Section 4.3.7.1</u>). The coastline also provides a habitat for many taonga (treasure) species including the kuaka (Godwit) with which Te Aupōuri hold a particular cultural, spiritual, historical and traditional association (Te Aupouri and the Crown, 2012).

4.3.6.2 Waikato

The Waikato region is home to the Tainui confederation of iwi which comprises Ngāti Whātua, Ngāti Mahuta, Ngāti Te Ata, Ngāti Raukawa and Ngāti Maniopoto (which straddles

81



the boundary between Waikato and Taranaki). All of these iwi are kaitiaki for their respective rohe moana (<u>Figure 38</u>) which collectively span a large stretch of the coastline considered in this MMIA and encompass key habitats such as the Kaipara, Manukau, Aotea, Raglan and Kawhia Harbours.

The harbours within the Waikato-Tainui rohe contain many significant historical features. Kawhia harbour in particular is of importance as it is the final resting place for the Tainui waka. After landing on the east coast and being dragged across land to Manukau, the waka explored the coastline, first heading north to Kaipara harbour then south towards Mokau (where its anchor stone was left) and finally Kawhia where it was hauled ashore. The spot is marked by two limestone pillars and is the reason why Kawhia is known as the spiritual and ancestral home of Tainui (kawhia.moari.nz, 2014).

Similarly to Northland, the harbours of Waikato were host to early Māori settlements and provided many traditional food-gathering sites. The natural resources of coastline provide sustenance and identity to Māori with species such as pingao (plant used for weaving), patiki (flounder), matamata (flounder) and kuaka (godwits) deemed particularly valuable. Wetlands are equally esteemed for their spawning grounds, and the fish and other taonga species that they harbour. In their Environmental Management Plan (2013) Waikato-Tainui also recognises the ecosystem services rendered by these habitats.

As a result of this cultural and natural heritage, waahi tapu are numerous in the Tainui-Waikato rohe and a proportion of these can be found along the coastline (Tainui Waikato, 2013). In particular, the dunes in the Waikato region contain many sites of significance including middens, remains of general living areas and urupa (burial grounds) (Waikato Region Council, 2014).

The mauri of the coastline within the rohe is critical to Waikato-Tainui. The main issues of concern are fisheries (see Section 4.3.7.2) and any activity which could impact thereupon (Tainui Waikato, 2013).

4.3.6.3 Taranaki

The Taranaki coastline is subdivided among eight iwi: Ngāti Tama, Ngāti Mutunga, Te Ātiawa, Taranaki, Ngā Ruahine, Ngāti Ruānui, Ngā Rauru and Ngati Maru (<u>Figure 38</u>). Māori settlers first arrived in the region between 1250 and 1300 AD but in the early 1800 war parties descended into Taranaki and many people migrated south.

The Mohakatino coastal region is a testimony to this troubled past as it was the scene of numerous battles between Ngāti Tama and northern iwi and now contains numerous urupa (burial sites). The disputed nature of this land has also contributed to the value of the Mātaitai resources in the area (Taranaki Regional Council (TRC), 2014b).

The coastal strip extending south from Pukearuhe to Mimi also contains many washi tapu sites. In particular, the pā sites (Māori villages - Titooki, Whakarewa, Otumatua and Pukearuhe) and the cliffs in the area are central to Ngāti Tama heritage. The cliffs were used to develop a unique fishing technique applied to catch mako (shark), tamure (snapper), and araara (trevally). Additionally, they contained many tauranga waka (canoe berths) which have now become "physical symbols of an historical association" with the area (Taranaki Regional Council (TRC), 2014b). The Paraninihi Reserve is located along this coastline and is managed using an "integrated management approach" which involves Ngāti Tama iwi authority in decision making alongside DOC and the Conservation Board (Department of Conservation (DOC), 2014).

Ngāti Mutunga iwi's strong sense of tradition illustrates its cultural, historical and spiritual links to the marine environment. The iwi heavily relies on natural resources as food supplies and to this day, food is gathered within the rohe moana between Titoki Ridge and Waiau Stream according to the values and tikanga of the iwi (see <u>Section 4.3.7.3</u>). Similarly to Ngāti Tama, Ngāti Mutunga used the cliffs to fish mako (shark), tamure (snapper), kahawai,



and araara (trevally). These cliffs also hold numerous tauranga waka (canoe berths) (Ngāti Mutunga lwi, 2014).

Te Ātiawa rohe ranges from Te Rau o te Huia to Herekawe Stream. Historically, Te Ātiawa people migrated south in large numbers in response to attacks from northern iwi. Many Te Ātiawa people returned to Taranaki in the middle of the 19th century (Te Ātiawa Taranaki, 2014). As with all coastal iwi, many heritage features including wahi tapu and traditional food gathering sites lie along the coastline of this rohe. Te Ātiawa iwi authority applied for a recognition agreement with the crown which was subsequently confirmed and covers the common marine and coastal area extending from the Herekawe Stream to the Onaero River in Te Atiawa's rohe (from mean high water springs on the landward side, out to 12 Nm) (Ministry of Justice, 2014).

Numerous sites of significance can be found along the coastline between Onukutaipari to Ouri Stream. Kaimoana reefs and waahi tapu which hold particular meaning to Taranaki iwi are counted among them (although these have not yet all been located – a mapping pilot is underway). Moreover, Taranaki iwi places substantial historical and spiritual importance in the Sugar Loaf (Ngā Motu) Islands (Taranaki Iwi Trust, 2013).

Nga Ruahine cite a "longstanding association with the coastal and marine environment and the life-forms within it" in their Environmental Management Plan (2000). The plan also lists numerous waahi tapu sites that can be found in the rohe including waahi ana (important cave areas), mahinga kai (places where food was produced or gathered), waahi paripari (cliff areas), Tauranga waka, waahi kaitiaki (resource indicators for the environment), urupa (burial sites), and pā Tawhito (ancient pā sites) (Te Runanga o Ngāti Rianui Trust, 2000).

The Marine and Coastal Area (Takutai Moana) Act 2011 (MACA) is an Act of the Parliament of NZ created to replace the Foreshore and Seabed Act 2004. The MACA guarantees free public access, makes a common space of the public marine and coastal area and protects all existing uses.

In 2012, Nga Hapu o Ngaruahine Iwi Inc submitted an application for protected customary rights and customary marine title through recognition agreement with the Crown under s62 of the MACA. The application which has been approved is for the common marine and coastal area between the Taungatara and Waihi Rivers. The common marine and coastal area covers the 'wet' part of the beach that is covered by the ebb and flow of the tide and extends to the outer limits of the territorial sea (12 Nm from shore).

The Ngāti Ruanui rohe covers the shoreline between Waingongoro River and Whenuakura River. The iwi relies on the hidden reefs within the marine environment for the provision of kaimoana (see Section 4.3.7.3). Tragedies have been linked to these reefs including the wreckage of a Chinese trade ship. When the bodies of the crew were washed ashore, they had no eyes and it was thought that they been eaten by the Ngāti Ruanui taniwha named Toi kaitiaki of the fishing grounds (Taranaki Regional Council (TRC), 2014a).

The area between Rangitaawhi and Wai-o-Turi Marae is "Te Kiki o Rauru" (the skin of Rauru) and constitutes a "life force" which contributes to the physical and spiritual well-being of Ngā Rauru Kiitahi. The coast is an important source of kaimoana (Section 4.3.7.3) and includes many sites of cultural, historical and spiritual significance to Ngā Rauru Kiitahi. These include Tihoi Pa (where te Rauparaha rested), Poopoia (Te kaainga a Aokehu), and Te Wai of Mahuka (near Te Ihonga) (Taranaki Regional Council (TRC), 2014c).



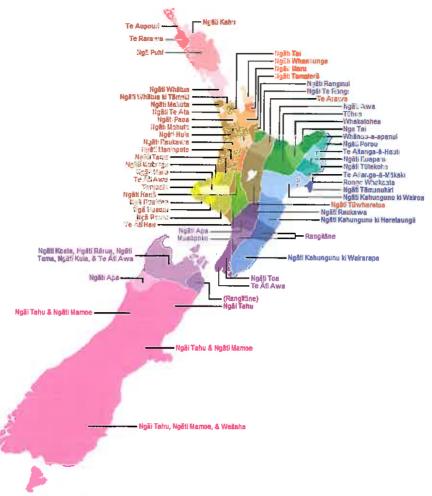


Figure 38: New Zealand Iwi boundaries

4.3.7 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 for 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. The following sections aim to highlight the main areas of concern to particular iwi and existing Taiapure and Mātaitai.



4.3.7.1 Northland

Ninety mile beach is vital to Te Aupōuri in providing kaimoana mainly in the form of tuatua, pipi, fish, pāua, mussels and kina. Currently, the main area of concern lies with the toheroa which is an endemic bivalve species. The latter half of the twentieth century saw a massive depletion in the toheroa stocks which remain low to this day (Te Aupouri and the Crown, 2012).

lwi are also particularly concerned about the state of the fish stocks in the north Hokianga region. The mudflats in the harbour are an important source of kaimoana (i.e. pipi) and traditional food-gathering sites are considered as "integral parts of the local Māori cultural landscape" and a number of these have been destroyed by mudflat reclamation in the area (Te Uira Associates, 2004).

4.3.7.2 Waikato

Fisheries play a central role in Waikato-Tainui culture. Taonga fish species are recognised as "the most common form of taniwha (spiritual beings)". Taonga species include tuna (short-finned and long-finned eels), whitebait species, smelt, piiharau (lamprey eels), kanae (mullet – yellow-eyed and grey), paatiki (flounder – yellow-bellied) kahawai, trevally and tamure (snapper), wheke (octopus), koura (freshwater crayfish), kaaeo and kaakahi (freshwater mussels), tio (oyster), pipi, kina and kuutai (green-lipped mussel) and marine mammals (Tainui Waikato, 2013).

4.3.7.3 Taranaki

Taranaki iwi regard pāua as taonga and it is highly valued as kaimoana. Pāua along the Taranaki region only seem to attain a maximum size of about 90-100 mm shell length, and do not appear to reach the national minimum legal size, and are commonly referred to as 'stunted". It has been shown that about 50% of Taranaki pāua mature at about 60 mm and 95% at about 75 mm. As a result, an amendment was made to the minimum legal size under the Fisheries (Central Area Amateur Fishing) Regulations 1986 to reduce the minimum legal size to 85 mm. This reduction in size was strongly opposed by customary interests as it was believed that recreational fishing pressure would deplete the pāua resource; thereby affecting the ability to harvest pāua for customary needs.

The different life stage cycles of the longfin eel are very important to Māori, in particular the migration of the longfin eel and the return of the glass eel. The longfin eel is an important resource for Māori, both commercially and non-commercially as it provides an important food source and has done so for many years so this species of eel is of significant cultural importance. Longfin eels are only found in NZ and is believed to be NZ's most widely distributed freshwater fish.

NZ longfin eels breed only once at the end of their lifecycle, where they migrate to their spawning grounds, which although the exact breeding location is unknown, is believed to be near Tonga or east of New Caledonia (Manaaki Tuna, 2014). After the eggs are fertilised which is thought to occur in deep tropical water the mature eels subsequently die and the eggs float to the surface and drift with the South Equatorial Current back to NZ which can take up to 18 months (Manaaki Tuna, 2014). Once the eel larvae reach NZ waters, they undergo a transformation into glass eels, which are essentially juvenile transparent adult eels. The glass eels arrive at NZ's coastlines from July to December with numbers peaking in spring (August-October) which coincides with the whitebait migration. When the glass eels enter the estuaries they develop colouration and transform into elvers where they migrate upstream to develop into adults. As longfin eels reach breeding size, they undergo a physical transformation. The eels change from 'yellow-bellies' to 'silver-bellies', they cease to feed and the stomach shrinks as the sexual organs grow large, parts of their body darken, the head changes shape and the pectoral fins and eyes enlarge (Manaaki Tuna, 2014). Longfin male eels start their migration in April with females soon following them. It is



believed the longfin male eel migrates at an average age of 23 years, while females have an average age of 34 years. It is unknown how long the journey takes, however one female longfin eel tagged from Canterbury's Lake Ellesmere travelled 160 km to northeast of New Caledonia in 161 days (Te Ara, 2014g). The exact migration route of these longfin eels is still unknown but research is being undertaken by NIVVA to identify their migration routes and destination utilising pop off tags. The NWF 2D MSS is likely to be completed by the start of northward migration of adult eels, however there is uncertainty of this migration period, but given the large size of these eels when they migrate there is likely to be very little interference from the NWF 2D MSS. The adult longfin eel migration path is also unknown, i.e. along the coast or further offshore as the eels travel towards Tonga. The most sensitive stage of the longfin's life cycle would be the return of the larvae and glass eels. It is assumed from Section 4.2.1, that like plankton, the eel larvae would have to be <5 m from the acoustic source for there to be any potential effects on these larvae. However, given the proposed timing of the NWF 2D MSS (start of December) it should not interfere with the return of the longfin eel larvae (July-December).

There are a number of marine species which Taranaki iwi value highly and include snapper, kahawai, blue cod, flat fish, grey mullet, sea urchin (kina), mussels and paua.

Flounder and snapper breeding grounds are particularly significant to Ngati Tama, who also rely on the harvesting of koura, mussels, kina and paua to supplement their diet (Taranaki Regional Council (TRC), 2014b).

The Taranaki coastline is of great spiritual and historical importance to Ngati Mutunga. Species such as pupu (cats eye), papaka (crabs), pipi and tuatua were harvested off the reefs, while hapūku (groper), moki, kanae (mullet), mako shark, flounder and snapper were fished in the waters surrounding (Taranaki Regional Council (TRC), 2014d).

For Ngati Ruanui, koura, pāua, kina, pupu, Papaka, tuatua and other marine species are culturally important (Taranaki Regional Council (TRC), 2014a).

4.3.7.4 Taiapure, Mataitai and Rohe Moana

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 are composed 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.

A rohe moana comprises of areas where Kaitiaki are appointed for the management of customary kaimoana collection within the area/rohe under the Kaimoana Customary Fishing Regulations (1998). The Customary Fishing Regulations allow hapu 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 over-exploitation.



There are three customary fishing reserves in the vicinity of the NWF Operational Area: Aotea Harbour Mātaitai, the Marokopa Mātaitai and the Kawhia Aotea Taiapure (<u>Figure 39</u>). Aotea Harbour Mātaitai covers approximatively 40 km² including coastal and harbour waters (MPI, 2008). Marokopa Mātaitai extends between Harihari Beach and Tirua Point and 3km out to sea. The total area spans 68 km² and includes all estuarine waters (MPI, 2010). The Kawhia Aotea Taiapure includes two areas: Kawhia harbour waters and adjacent coastal waters, and a zone of 1 Nm radius around Gannet Island (Michael Hardie Boys, 2000).

There are six rohe moana's which extend from the coastline out to the EEZ and pass through the NWF Operational Area (<u>Figure 40</u>). The purpose of the rohe moana's is for the better provision for the recognition of Rangitiratanga (sovereignty) and of the right secured in relation to fisheries by Article II of the Treaty of Waitangi. The hapu for these areas are Ngati Te Ata, Nga Kaitiaki o Te Puaha, Ngati Tahinga (Pukerewa and Weraroa Marae), Ngati Tahinga (Te Akau Marae), Ngati Mahanga, Nga Toko Toru, Tamainupo, Tainui-Tahinga and Ngati Tamainupo.

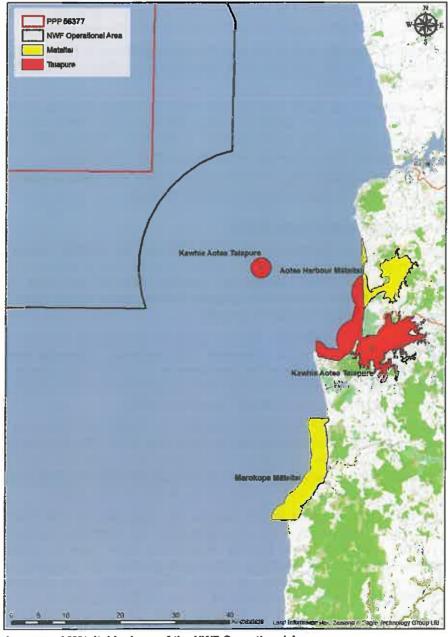


Figure 39: Talapure and Mātaitai inshore of the NWF Operational Area



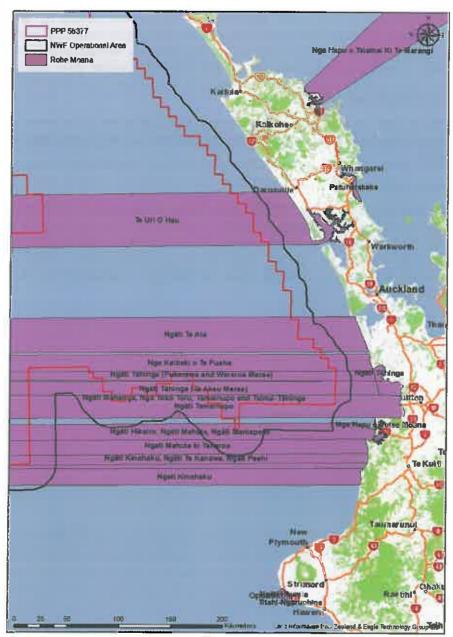


Figure 40: Rohe Moana around the NWF Operational Area

4.4 Anthropogenic Environment

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

4.4.1 Recreational Fishing

The NWF Operational Area is not often fished by recreational fishers due to its distance offshore (entirely beyond the 12 Nm CMA) and most of the NWF 2D MSS will be acquired in water depths of greater than 300 m.

However, inshore of the NWF Operational Area supports significant recreational fisheries for snapper, kingfish, hapūku/bass, trevally, kahawai, tarakihi, blue cod, blue nose, gurnard, pāua, mussels, trumpeter, ling, albacore, butterfish, sea perch, kina, blue moki and crayfish.



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.

Notifications have been sent out to the sport fishing clubs along the coastline inshore of the NWF Operational Area which will inform fishers of the NWF 2D MSS and help alleviate any potential conflict.

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 (<u>Figure 41</u>). Over 1,000 fish species occur in NZ waters (Te Ara, 2014d) of which the QMS provides for 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.



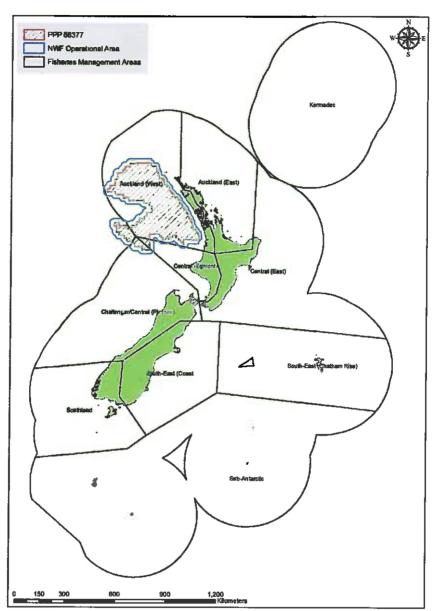


Figure 41: Fisheries management areas within NZ waters

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 within PPP 56377 for the 2008/09 – 2012/13 fishing years which has been used within this MMIA to provide a summary of commercial fishing activities and what species are targeted. As well as this, and as part of the consultation process, the Deepwater Group and commercial fishing companies have been directly engaged with and the seismic survey has been discussed in detail.

Data was analysed for all fishing events that started, passed through or ended within PPP 56377. The estimated catch of the top five species from fishing events that started, passed through or ended within PPP 56377 is shown in <u>Table 10</u> with jack mackerel having the biggest landings returned. When fishing events were assessed by target species, the most commonly targeted species within PPP 56377 were orange roughy, jack mackerel, ling, tarakihi and bluenose.



Table 10: Top five species caught in PPP 56377 during 2008/09 - 2012/13 fishing year (tonnes)

Species	Total (tonnes)
Jack Mackerel	14,199
Skip Jack Tuna	1,363
Barracouta	588
Frostfish	351
Blue Mackerel	262
Others	1,172
Total	17,936

The three most common fishing methods used within PPP 56377 are: trawling, bottom longlining and surface longlining. The number of fishing events by fishing method that started or ended in PPP 56377 during the 2008/09 – 2012/13 fishing years can be seen in Table 11. Over the five years considered within the fishery assessment, trawling has been the most commonly used fishing method within PPP 56377, although there is a considerable amount of bottom longlining and a small amount of surface longlining activity.

Table 11: Fishing events by method within PPP 56377 during 2008/09 - 2012/13

Method	2008/09	2009/10	2010/11	2011/12	2012/13	Total
Trawl	605	454	509	632	811	3,011
Bottom longline	268	320	429	276	156	1,449
Surface longline	36	51	62	59	101	309
Other	16	76	21	77	73	263
Total	925	901	1,021	1,044	1,141	5,032

Plots of trawling activity by month demonstrated that most of the fishing using this method is undertaken from October to March. This coincides with the new fishing year when quota becomes available again and the more settled weather (Figure 42). Trawling mainly occurs inshore along the eastern edge of PPP 56377 (from the southern boundary up to the tip of Northland) with the exception of a few clustered fishing events recorded in the northwestern and western sections of PPP 56377, representing the Challenger Plateau and around the West Norfolk Ridge and Wanganella Banks (Figure 43).

Bottom longline fishing events appear to take place year-round with a slight decrease between May and July (<u>Figure 42</u>), coinciding with the more adverse sea conditions. It can be seen that bottom fishing intensity (both trawling and bottom longlining) generally occurs within the inshore section of PPP 56377 along the west coast of the North Island (<u>Figure 44</u>).



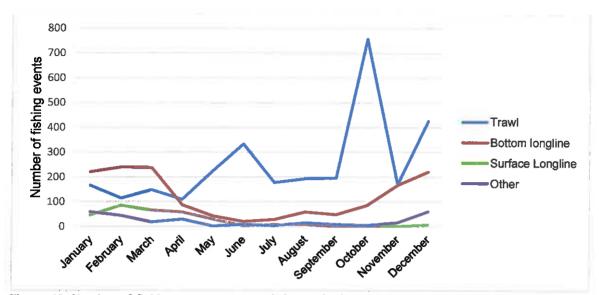


Figure 42: Number of fishing events per month by method within PPP 56377 during 2008/09 - 2012/13 fishing years

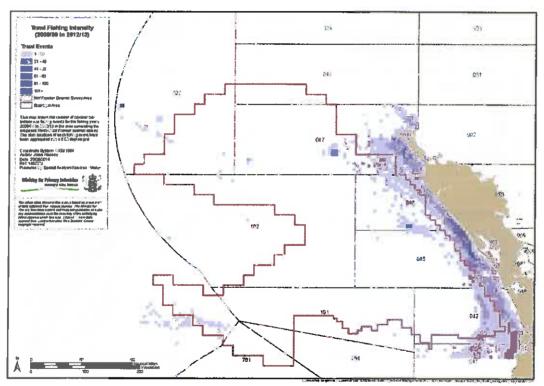


Figure 43: Intensity of trawl fishing activity in and around the proposed seismic survey area based on aggregated data from the 2008/09 to 2012/13 fishing years

In contrast, surface longlining is mainly restricted to January-June when the waters are warmer and pelagic fish are present (<u>Figure 42</u>). Surface longlining events are scattered slightly further offshore than trawling and bottom longlining fishing events but still remain in the eastern section of PPP 56377 (<u>Figure 45</u>).

The 2008/09-2012/13 data also indicated that, overall, other methods of fishing are concentrated between November and April (Figure 42) and along the eastern boundary of the PPP 56377 (Figure 46 & Figure 47). The other methods of fishing include, set netting, Danish seine, purse seining and potting.



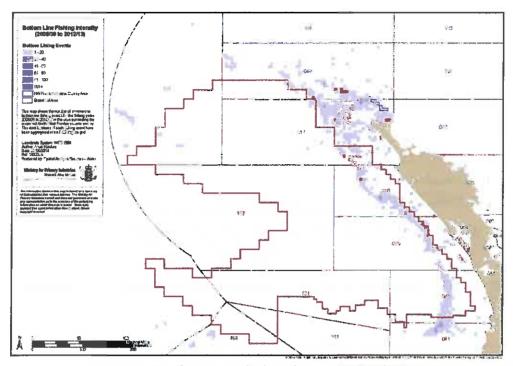


Figure 44: Intensity of bottom longline fishing activity in and around PPP 56377 based on aggregated data from the 2008/09 to 2012/13 fishing years

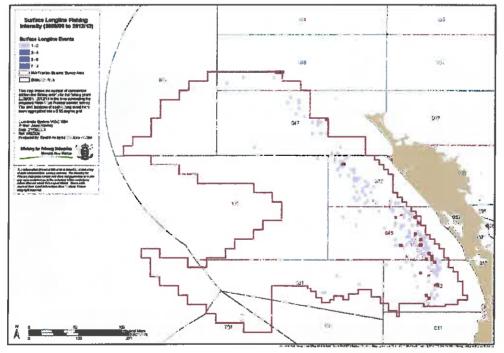


Figure 45: Intensity of surface longline fishing activity in and around PPP 56377 based on aggregated data from the 2008/09 to 2012/13 fishing years



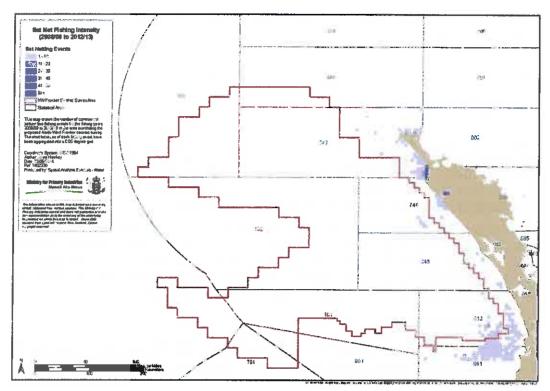


Figure 46: Intensity of set net fishing activity in and around PPP 56377 based on aggregated data from the 2008/09 to 2012/13 fishing years

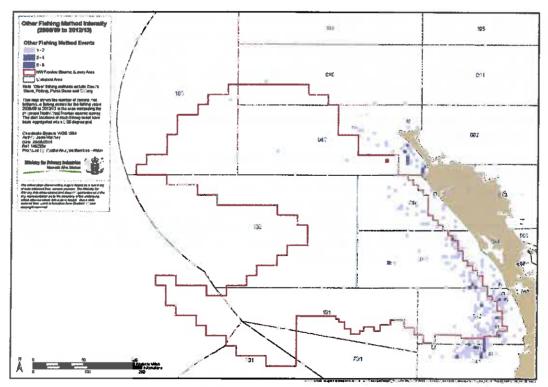


Figure 47: Intensity of fishing activity using other methods in and around PPP 56377 based on aggregated data from the 2008/09 to 2012/13 fishing years



The fishing industry has been notified of the proposed NWF 2D MSS (<u>Appendix 2</u>) and approximate commencement data, with all groups and fishers that utilise the area also notified.

Consultation has been undertaken with Deepwater Group, Sanford's, and Sealord, to advise them of the proposed NWF 2D MSS and the array of gear that will be behind the *Aquila Explorer*. Sanford's are going to represent the interests of the other fishing companies (i.e. Aotearoa Fisheries Limited, Talley's, Pelco) and a constant communication is to be in place between Sanford's and TGS. TGS are going to provide information of where the vessel is going to be operating for a period of time ahead and the actual acquisition of the NWF 2D MSS will be undertaken in a manner to try and reduce conflict with the fishing industry. A summary of the engagements is provided in <u>Appendix 2</u>. 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 NWF 2D 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 NWF 2D MSS and can provide more timely access to important navigation safety information.

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 NWF Operational Area is Port Taranaki, Taharoa Terminal and Port Onehunga (in Manukau Harbour).

Commercial shipping vessels generally use the most direct path when travelling between ports; the general shipping routes between NZ ports are shown in Figure 48. The NWF Operational Area is located offshore from the shipping route between Port Taranaki and Port Onehunga, and likewise Port Onehunga to the Ports of Auckland or the ports located along the east Coast of the North Island. However, those commercial vessels which travel from the east coast of the North Island to Port Taranaki are likely to round Cape Reinga and make a straight passage to Port Taranaki. This route will take these vessels through the NWF Operational Area. As a result, the ports along the east coast of the North Island have also been notified of the NWF 2D MSS.

Between the ports around NZ there is no dedicated shipping lane; vessels will generally take the shortest route with consideration of the weather conditions and forecast at the time. A Notice to Mariners will be issued ahead of the NWF 2D MSS commencing and with adherence of all vessels to the COLREGS there should be no conflict between shipping vessels and the *Aquila Explorer*. The routes for foreign destinations from NZ ports is likely to vary and has not been included in <u>Figure 48</u>, although it is likely they could pass through or in close proximity to the NWF Operational Area.



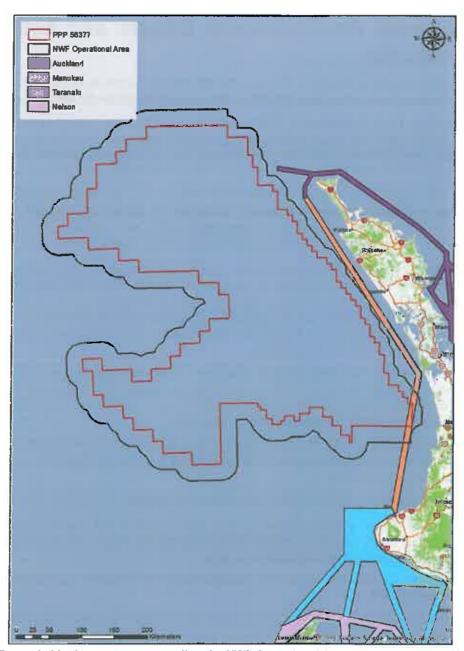


Figure 48: General shipping routes surrounding the NWF Operational Area

4.4.4 Petroleum Exploration

Until recently NZ has had limited exploration outside of the Taranaki Basin, and although the Taranaki Basin is NZ's premier oil and gas exploration region, other basins have started to attract significant interest as emerging basins of petroleum potential. The proposed survey area comprises the Reinga and New Caledonia Basins which extend northwesterly from the productive Taranaki Basin. The area is sparsely explored with only four wells drilled within the southeastern portion of the NWF Operational Area.

As the area is an extension of the Taranaki Basin, by analogy there is a variety of potential reservoir rocks spanning the entire age range of the sediments. The current limited well control indicates viable reservoir sandstones in the Paleocene (Waka Nui-1) and Pliocene (Karewa-1) sections. As those wells were drilled on structural highs, it is likely that many more reservoirs are present in other locations.



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 NWF 2D 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 12).

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). Environmental resources are components of the environment that are essential (or of value) to the functioning of natural human systems (e.g. seabed and water).

This assessment considers the consequence (<u>Table 13</u>) and likelihood (<u>Table 14</u>) of the potential environmental effect including its geographical scale (site, local and regional) and its duration in relation to the sensitivity of the key environmental receptors. A description of the risk matrix categories is provided in <u>Table 15</u>. A summary of the planned and unplanned activities with the consequence and likelihood scores as well as the overall risk ranking for the NWF 2D 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 <u>Table 12</u>. 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 (<u>Table 12</u>) is based on standard mitigation measures to avoid, remedy or mitigate environmental effects being in place and are discussed for each activity in the following sections.

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

- Identification of the activities (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 activities identified; and

Detailed description of each identified potential environmental effect, including the measures which TGS will undertake to control and mitigate each potential effect.



Table 12: Environmental Risk Assessment

		4 - Neattable	5 - Minor	¥ ≈ Moderats.	1 - Maror
Likelinod Calagary	1 Almost certain			Shim	former.
	2 - Lrkely	Mer	Madjum	100	Eires
	3 - Possible	1.60	Medium	Merium	-
	4 · Unitically		Low	Medium	

Consequence level	Marine Mammais (Species of Concern)	Environment & Recovery Period	Natural Environment and Ecosystem functional effects	Merine Fauna	Proportion of habitat affected	Existing interests (commercial tishers, recreational tishers, cultimation traffic)
4 - Negligible	No significant effects on marine mammals expected beyond 1.5 km from the accustic source. Validated by STLM where all SEL's are below the threshold of 171 dis r Jipa's, for behavioural effects to marine mammals within the Code of Conduct.	Localked effect (immediate area). Temporary impact (days).	Interactions may be occurring but it is untilially that there would be any change outside of natural variation. No lesting effects.	No detectable adverse effects to communities or populations of these species.	Measurable but localised, affecting 1- 5% of area of original hebitat area.	No effect. No negative interactions with existing interests to carry out their normal activities.
3 - Minur	Marine mammals between 1.5 km and 1 km from the ecoustic source could be slightly influenced by the emitted sound level. This correlates with the mitigation zones within the Code of Conduct for Species of Concern.	Rapid recovery would occur if stopped. Localised (<1 km²). Short term (we::ks) 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 lexystena role - only minor changes in relative abundance of other constituents.	Local short-term impact to communities and populations. Does not threaten viability of community or population.	Messurable but localised; patential effects are alightly more widespread; 5-20% of habitat area is affected.	Localised effect and short term impact. Recovery to the existing interest activities would occur if selemic activities stopped.
2 - Moderatu	Behaviour of marine mammals is likely to be influenced in a 200 m to 1 km zone from the acount's southed. Behavioural effects to marine mammals are likely to occur and physical effects may develop closer to the source, but is presumed to be temporary.	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.	Local medium-term impact to communities and populations. But long-term recruitment dynamics not adversely impacted.	Potential adverse effects more widespread; 20-80% of habitat is affected.	Recovery short term if seismic activities are stopped. Existing interests may have to after their activities as a result of the seismic operations for a short period of time.
1 Major	An environmental effect is likely to occur to marine mammals if they are within 200 m of the occusible source. The STLM showed that the SEL's are greater than 188 d3 re1 µPa's SEL within 200 m of the source which is the SEL believed to result in some form of injury to marine mammals as defined in the Code of Conduct	Recovery measured in months up to a year if selamic activities are stepped. Medium scale (10-100 km²).	A major change to ecosystem structure and funds 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 dreadedly reduced and most ecological functional groups (u-rimary producers etc.) have disappeared. Most ecosystem functions such as carbon cycling, nutrient cycling, flueting and uptake have declined to very fow levels.	Regional medium-term or local long-term impact to communities and populations. Affects recruitment levels of populations or their capacity to increase.	Activity may result in major changes to ecosystem or region; 60-100% of habitat effected.	Recovery longer term if schambe activities are stopped. Significant change required to the existing interests activities.



Table 14: 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 15: 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. Potential for uncontrollable negative public relations events.
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, remedy or mitigate 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 behaviour. 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 TGS.
Medium Risk:	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, natural marine environment or public relations from the seismic activities.



5.1 Planned Activities – Potential Effects & Mitigation Measures

5.1.1 Physical presence of Aquila Explorer and the Seismic Array

The *Aquila Explorer* and the associated seismic array has 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 NWF 2D MSS could interfere with fishing activities due to the length of seismic array towed behind the *Aquila Explorer*. As a result, fishing vessels (mainly commercial) will be caused a temporary loss or reduction of access to fishing grounds within the NWF Operational Area during the survey (~120-150 days).

Commercial fishers who use the NWF Operational Area as part of their fishing grounds have been advised of the NWF 2D MSS and will be contacted closer to commencement with further details. To date the communications have been positive with the commercial fishing industry (Appendix 2). The acquisition of the NWF 2D MSS could cause temporary displacement of fish stocks; however, most of the commercial fishing within the area is undertaken well inshore of the NWF 2D MSS Area.

There is no evidence that previous seismic surveys have had any effect on fisheries; however, if there was to be an effect, it is likely to be temporary and have no lasting harm to any fish populations.

Not all fishing methods will be impacted in the same way. Trawling is the most common method of commercial fishing in the waters within and surrounding the NWF 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 NWF 2D MSS. In contrast, surface long-lining provides the potential for heavier conflict. For this method of fishing, many kilometres of line is set and left for a number of hours.

To ensure that the potential environmental effects are minimised to ALARP, TGS 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 in close proximity; notify commercial fishers of the NWF 2D MSS and NWF Operational Area; issue a Notice to Mariners, have coastal navigation warnings broadcast and have a tail buoy attached to the end of the streamer to mark the overall extent of the seismic array to avoid any uncertainty.

With the mitigation measures in place, the environmental risk from the NWF 2D MSS on 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 NWF 2D MSS will not come into contact with the seabed or coastline inshore of the NWF Operational Area. The streamer used in the NWF 2D MSS has self-recovery devices fitted which release once the streamer reaches a certain depth (~50 m) bringing the streamer back to the surface for retrieval, in the unlikely event that the streamer be severed and start sinking. In addition, most of the areas that are culturally significant are on the intertidal and shallow sub-tidal reefs located inshore of the NWF Operational Area. Consequently, it would only be a rupture to the vessel's fuel tank that could cause these areas to be impacted. TGS have mitigation measures in place to avoid a collision or prevent a spill of fuel to the marine environment and are discussed in <u>Section 5.2.2</u>. Therefore, it is considered that the potential interference with any marine archaeology, cultural heritage or submarine infrastructure arising from the physical presence of the *Aquila Explorer* and the seismic array during the NWF 2D MSS is *Iow*.



5.1.1.3 Changes in Seabird Behaviour

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 (Black, 2005, Guynup, 2003).

There is limited experimental 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 and Kempf, 1998). Although 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 TGS 2D MSS. The *Aquila Explorer* will always be underway while acquiring the NWF 2D 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 <u>Section 5.1.2.2.3</u>). As a result, the physical presence of the *Aquila Explorer* and the seismic array during the NWF 2D MSS is considered to have *low* risk to seabirds.

5.1.1.4 Introduction of Marine Pest or Invasive Species

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

Most MSS vessels have their hulls regularly cleaned and painted with antifouling to prevent the establishment and growth of fouling communities. The *Aquila Explorer* was last slipped in November 2013 when the hull was cleaned and new antifoul paint was applied. This drydocking and antifouling will help minimise the risk of any invasive species entering NZ waters on the *Aquila Explorer's* hull or seachests. No ballast water will be discharged as part of the NWF 2D MSS, reducing the risk of introduction of any invasive species.

The support vessel *Ocean Pioneer* is based in NZ and poses no risk associated with ballast water or hull fouling of new organisms entering NZ waters, although there is the potential for invasive species within NZ to be transferred between regions. Therefore, the potential to introduce marine pests or invasive species as a result of the NWF 2D MSS is considered *low*.

5.1.1.5 Interaction of Aquila Explorer with Marine Mammals

The physical presence of the *Aquila Explorer* 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 *Aquila Explorer* 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 NWF Operational Area



without concentrating in a given 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 and Silber, 2003). Nine of these species are among those which are likely to occur within the NWF Operational Area (i.e. blue whale, Bryde's 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 (2003) 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 (2003) reported a mean speed of 18.6 kts for vessels involved in lethal ship strike. During acquisition, the *Aquila Explorer* will only be travelling at ~4.5 kts, under four times less than the mean speed reported in the Jensen & Silber (2003) study.

Given the information detailed above, it is considered that the risk to marine mammals arising from the physical presence of the *Aquila Explorer* and the seismic array during the NWF 2D MSS is *medium*.

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 it may reach background levels 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 detonation 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 focus on these sound waves generated from the acoustic source.

A high intensity external stimuli (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 punctual), 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 range from changes in behaviour with lesser or greater population wide impacts (displacement, surfacing too quickly from deep dives which can result in 'decompression sickness', disruption of feeding, breeding or nursery activities, interference in communication) 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, these potential behavioural and physiological effects discussed above are unlikely to occur or will be mitigated through compliance of the NWF 2D MSS with the Code of Conduct and associated mitigation measures. Adhering to these operating procedures (i.e. MMO's, PAM operators, soft starts, pre-survey observations) no marine mammals should enter the specified mitigation zones, exposing them to any SEL's above the thresholds for behaviour or injury criteria.

More specifically, the requirements and mitigation measures for a Level 1 MSS will be adhered to for the NWF 2D MSS and the acoustic source will either be shut down or delayed starts if any marine mammals are within the relevant mitigation zones and as a result keeping all impacts to a minimum level. TGS has undertaken source modelling to ensure the *Aquila Explorer* is using the minimum acoustic source volume required to achieve the objectives of the NWF 2D MSS, and the NWF Operational Area has been adjusted following the STLM (Section 5.1.2.1).

The following sections detail the emitted sound levels that will be produced by the NWF 2D MSS and discuss the predicted potential impacts on marine mammals and other fauna.

5.1.2.1 Sound Transmission Loss Modelling

TGS 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 SEL's from the NWF 2D MSS to assess for compliance with the mitigation zones in the Code of Conduct (<u>Appendix 5</u>). 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 NWF Operational Area (Koessler and Duncan, 2014b)

The NWF Operational Area covers a large geographic footprint and spans an area of complex bathymetry (Section 4.1.3). The offshore environment transitions from the continental shelf through the continental slope to the benthic regions, and as a result five different geoacoustic regions representing different bottom substrate types were chosen to represent the probable benthic sediment compositions and sub-bottom layering within PPP 56377 (Figure 49). The information was obtained from published literature on NZ regional seabed geology and the acoustic properties of marine sediments (Koessler and Duncan, 2014b). 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 Koessler & Duncan (2014):

- R1:Taranaki Northland Continental Shelf (Fine sand);
- R2: Taranaki Northland Continental Slope (Silt Clay);
- R3: Southern New Caledonia Basin Reinga Basin Challenger Plateau (Pelagic Sediments, Mud-Oozes);
- R4: Veining Meinez Fracture Zone Reinga Ridge (Carbonate Sediments); and
- R5: Norfolk Ridge Wanganella Ridge (Sedimentary Rock (Limestone).



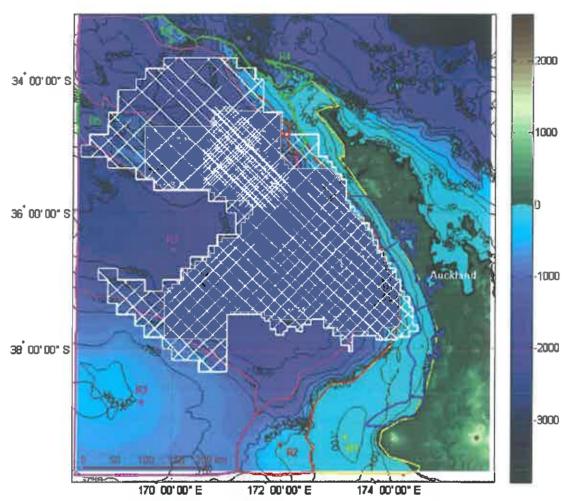


Figure 49: Geoacoustic Regions within PPP 56377

STLM was conducted at seven modelling locations within PPP 56377. S1, S2 and S3 are shown in <u>Figure 50</u>, while S2, S3, S4, S5, S6 &S7 are shown in <u>Figure 51</u>. S1 was located in PEP 55781 which is also within PPP 56377.

The modelling was based on the proposed NWF 2D MSS acoustic source (4,400 in³) while a comparison was also made at S1 to a 4,140 in³ acoustic source which was used for the acquisition of the Reinga MSS in 2009. The modelling locations were selected based on the greatest potential for sound and energy propagation. The acoustic source was modelled to be operating 8 m below the sea surface - received sound levels in the water column increase with increasing array depth.



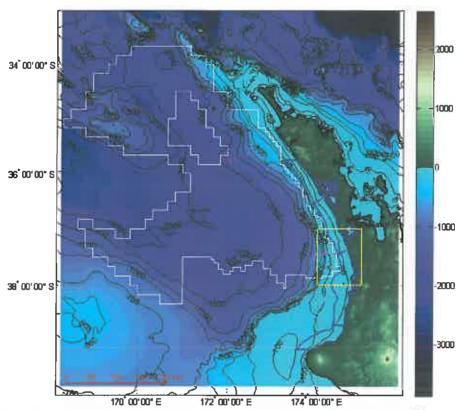


Figure 50: Modelling locations (S1, S2 & S3) and geoacoustic regions within PPP 56377. Yellow box is shown in Figure 51

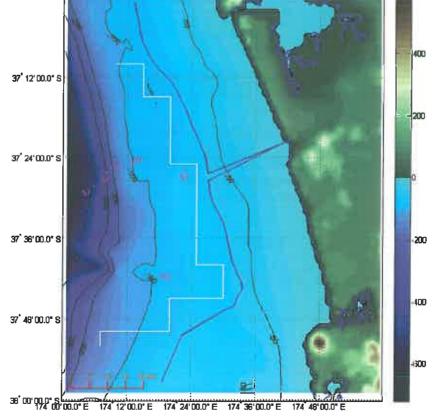


Figure 51: Source locations S2, S3, S4, S5 S6 & S7 within PPP 56377



5.1.2.1.1 Water-column Properties

The water column properties utilised within the STLM were based on the sound speed profiles derived from the closest grid point in the southern hemisphere to PPP 56377 and were calculated from temperature and salinity data from the World Ocean Atlas (Koessler and Duncan, 2014b). The data was averaged into three month blocks to represent the seasons: January to March (summer), April to June (autumn), July to September (winter) and October to December (spring) (Figure 52). During spring and summer there is a strong seasonal thermocline in the upper part of the water column that results in a downwardly refracting near-surface sound speed profile, while in autumn there is a weak surface duct and a strong surface duct in winter.

As a result of this a near-surface acoustic source (i.e. acoustic array) would be expected to produce its lowest range levels in spring in summer, moderate levels in autumn and its highest levels in winter. For the NWF 2D MSS the autumn speed profile was chosen for the STLM in order to capture the worst-case conditions that could be encountered towards the end of the NWF 2D MSS.

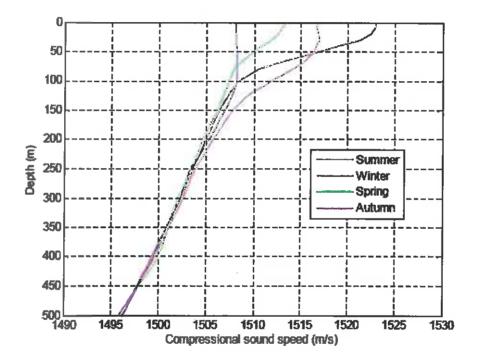


Figure 52: Sound speed profiles derived from the World Ocean Atlas (2005) for the southern hemisphere seasons

5.1.2.1.2 Short Range Modelling

The STLM used vertical and horizontal cross-sections through the frequency dependent beam patterns 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 energy is radiated in the in-line direction (azimuths of 0° and 180°) as a result of the acoustic source configuration (<u>Figure 53</u> and <u>Figure 54</u>). A significant amount of energy is radiated in the cross-line direction but only to mid-frequencies. These beam patterns are characteristic of an acoustic array with wide spacing between elements or in the case of the NWF 2D MSS, wide spacing between the sub-arrays.

<u>Figure 53</u> indicates the maximum received SEL's at location S1 which is within PPP 56377 and PEP 55781, while <u>Figure 54</u> is located at S3 in the southeast corner of PPP 56377 (Figure 51). The mitigation zones within the Code of Conduct are shown in Figure 53 and



<u>Figure 54</u>, 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 SEL's.

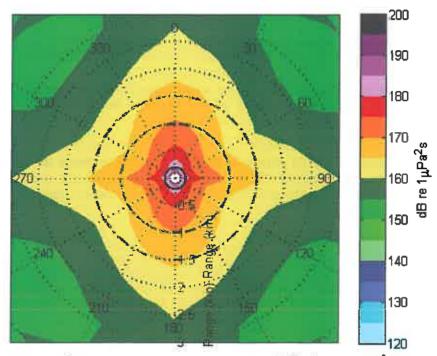


Figure 53: Maximum received SEL's at any depth from the Aquila Explorer 4,400 in³ acoustic source at S1

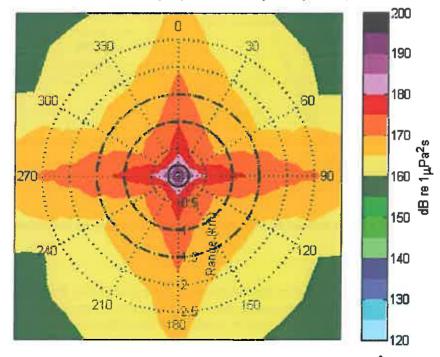


Figure 54: Maximum received SEL's at any depth from the Aquila Explorer 4,400 in³ acoustic source at S3

S3 is located within the shallowest depth (70.7 m) of PPP 56377 and over an acoustically reflective seabed to take a conservative approach and present 'worst case', given the highest short range received SEL's occur in shallow water due to the contribution of acoustic energy reflected from the seabed, while lower received SEL's result when the source is operating in deeper waters as can be seen in <u>Table 16</u>.



The initial modelling by Koessler & Duncan (2014) showed that at S3 the SEL's were greater than 171 dB re 1 μ Pa².s (behaviour criteria) and 186 dB re 1 μ Pa².s (injury criteria) at the respective mitigation zones within the Code of Conduct. As a result, TGS requested additional modelling in deeper water to be undertaken to determine at what distances from the acoustic source the SEL's were 100% below the levels stipulated within the Code of Conduct for behaviour and injury criteria (Table 16). Four additional source locations (S4, S5, S6 and S7) were included offshore from S3 at depths of 100 m, 220 m, 300 m and 494 m.

Table 16: Ranges at which SEL's drop below thresholds in both shallow and deep waters

Thresholds			S3 (70.7 m)	S4 (100 m)	S5 (220 m)	S6 (300 m)	S7 (494 m)
186 dB μPa².s	re	1	270 m	250 m	210 m	175 m	180 m
171 dΒ μPa².s	re	1	2 ,240 m	1,970 m	1,290 m	940 m	835 m

At each of the source locations modelled in <u>Table 16</u> the maximum SEL's were calculated at the three mitigation zones within the Code of Conduct (<u>Table 17</u>). This further supports what is discussed above, where the higher SEL's occur in the shallower water due to short range reflections from the seabed, the reflective nature of the seabed and the large total volume of the acoustic source array.

Table 17: Maximum SEL at the 200 m, 1 km and 1.5 km mitigation zones

	SEL at 200 m (dB re 1 µPa².s)	SEL at 1 km (dB re 1 μPa².s)	SEL at 1.5 km (dB re 1 µPa².s)
S3 (70.7 m)	188.2	176.3	173.9
S4 (100 m)	187.5	174.7	172.4
S5 (220 m)	186.3	173.3	168.9
S6 (300 m)	184.9	170.5	169.3
S7 (494 m)	184.7	169.3	166.6

A scatter plot was produced for the maximum predicted SEL's at S3, S4, S5, S6 and S7 as a function of range (<u>Figure 55</u>). The different coloured dots represent the SEL at different water depths and is a representation of the resulted tabulated within <u>Table 17</u>.



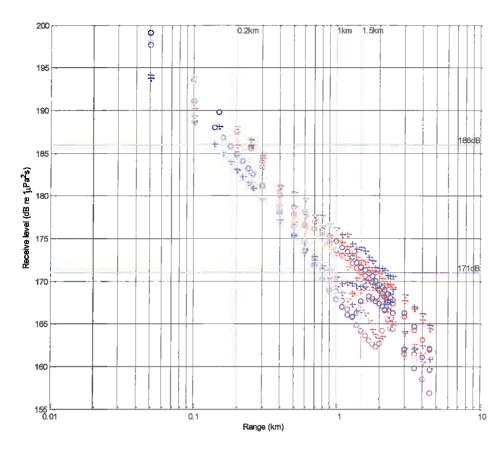


Figure 55: Scatter plot of SELs in the cross-line direction (crosses) and in-line direction (circles) at S3 (black), S4 (red), S5 (brown), S6 (blue) and S7 (magenta). Vertical magenta lines show mitigation ranges of 200 m, 1 km and 1.5 km, while horizontal green lines show mitigation thresholds

The Code of Conduct states that if the STLM shows the SEL's are predicted to exceed either 171 dB re 1 μ Pa².s at distances corresponding to the relevant mitigation zones for Species of Concern, or 186 dB re 1 μ Pa².s at 200 m, consideration will be given to either extending the radius of the mitigation zone or limiting the acoustic source power accordingly. However due to the depth of the targets below the seabed TGS are aiming for in the deep water the acoustic source cannot be reduced as this will jeopardise the survey results.

As a result, additional modelling was undertaken at S4, S5, S6 and S7 to determine at what depths the maximum SEL's are below the thresholds to ensure compliance with the Code of Conduct (Table 17) within the NWF Operational Area.

Following an assessment of the STLM outputs, TGS refined the NWF 2D MSS to eliminate most of the survey lines in water depths less than 300 m apart from the southeast corner where the well ties will take place. Modelled SEL's from S6 are below the thresholds stipulated in the Code of Conduct (184.9 dB re 1 μ Pa²s at 200 m range; 170.5 dB re 1 μ Pa²s at 1 km range and 169.3 dB re 1 μ Pa²s at 1.5 km range). Refining the NWF Survey Area to mostly beyond the 300 m depth contour creates a larger "buffer zone" between the inshore boundary of the NWF Survey Area and the west coast North Island MMS, thus decreasing and further mitigating the potential impact on this particularly sensitive section of coastline.

In the southeast corner of the NWF Survey Area where the well ties will take place, the Tarapunga-1 well is located in water depths of 110 m and the Korimako-1 well is located in 105 m. So given the water depths are shallower than the 300 m contour line, the NWF 2D MSS cannot adhere to the standard mitigation zones stipulated within the Code of Conduct for this southeast corner. As a result, additional mitigation will be put in place in the southeast corner of the NWF Operational Area through the extension of the mitigation zones in alignment with the STLM. Figure 56 shows the area whereby when the vessel enters, the



mitigation zones will increase to 2 km for Species of Concern with or without calf to reflect the SELs predicted at S4 in a water depth of 100 m. For all other marine mammals the mitigation zone will increase from 200 m to 250 m. Using these increased mitigation zones for the southeast corner of the NWF Operational Area, it will ensure that no cetacean will be in contact with the SEL thresholds that may affect their behaviour.

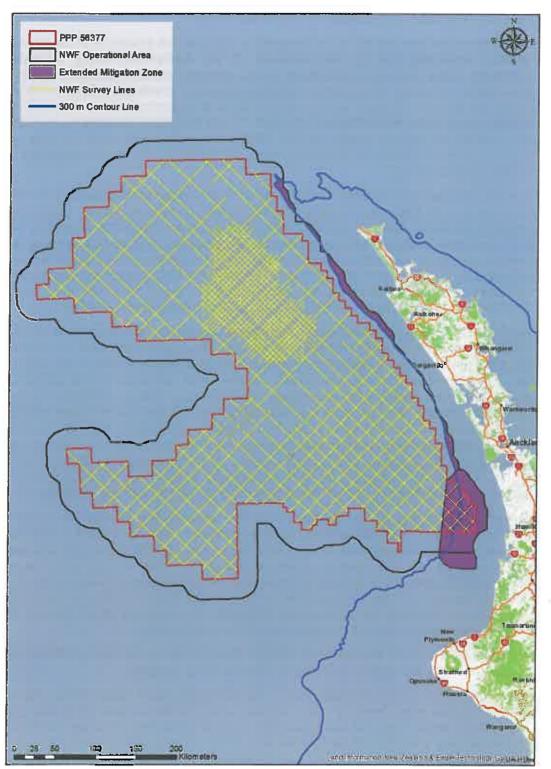


Figure 56: Increased Mitigation zone of 2km will be implemented in less than 300 m (purple area).



5.1.2.1.3 Long Range Modelling

Long range modelling was undertaken at S2 out to a 400 km radius (<u>Figure 57</u>) and a 80 km radius (<u>Figure 58</u>), with the S2 location being selected on the assumption that it was the location most likely to produce the highest SEL's within PPP 56377 towards the west coast North Island MMS. TGS selected a conservative approach for the long range modelling, where the source location was selected to model worst case.

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. However, there are some limitations to the accuracy of this approach, which are discussed below. Whereas, short range modelling procedure precludes taking variations in topography into account, however such variations would be expected to have minimal impact on predicted sound levels at the 200 m, 1 km and 1.5 km mitigation specified in the Code of Conduct. Within the inshore section of PPP 56377, the bathymetry does not drop away sharply so the potential limitations discussed above are not likely to present themselves from the modelled location at S2.

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.

Long range STLM (Figure 57) identifies the strong and complicated directionality of the SEL's due to a combination of the directionality of the acoustic array, which produces the maximum amount of radiated energy in the in-line direction and to a lesser extent in the cross line direction. The effect of variable bathymetry causes rapid attenuation upslope from the source and enhances propagation downslope (Koessler and Duncan, 2014a). 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.

This is illustrated in <u>Figure 59</u> which shows a vertical cross-section through the sound field produced by the source modelled at the long-range modelling location S2 within PPP 56377 in the in-line direction (along 130 °T and 310 °T). The highest SEL's are transmitted vertically downward 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 (Koessler and Duncan, 2014a). Shorewards from the source the sound field is fairly uniform vertically, whereas offshore the downwardly refracting sound speed profile results in the higher sound levels being found in the lower half of the water column.

<u>Figure 60</u> shows a second vertical cross-section through the sound field produced by an acoustic source at S2, although in this case for the cross-line direction.

To assess what SEL's could potentially reach the west coast North Island MMS long range modelling at S2 in a water depth of 100 m out to a range of 80 km was conducted (<u>Figure 58</u>). The STLM indicated that the maximum SEL's at the offshore west coast North Island MMS boundary was predicted to be 145 dB re 1 μ Pa².s which is well below the 171 dB re 1 μ Pa².s stated within the Code of Conduct and is believed to potentially affect the behaviour of marine mammals (DOC, 2013).



However, TGS have refined the NWF 2D MSS so that the most of the survey will be acquired in water depths deeper than 300 m. Long range STLM was also undertaken at S6 out to 80 km to assess what the SEL was at the west coast North Island MMS (Figure 61). S6 is located in a water depth of 300 m and is 26 km from the outer MMS boundary. From the S6 location, STLM results predicted that the NWF 2D MSS would produce maximum levels of 127 dB re 1 μ Pa².s at the offshore boundary of the west coast North Island MMS.

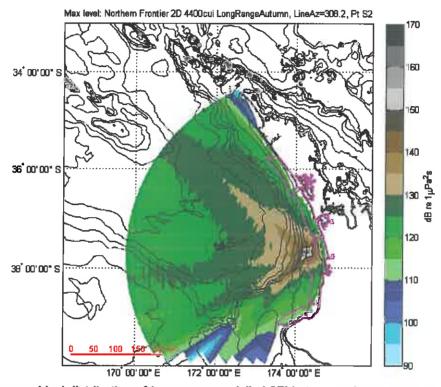


Figure 57: Geographical distribution of long range modelled SEL's to a maximum range of 400 km at S2. Survey line azimuth is 308°T. West Coast North Island Marine Mammal Sanctuary is plotted in magenta



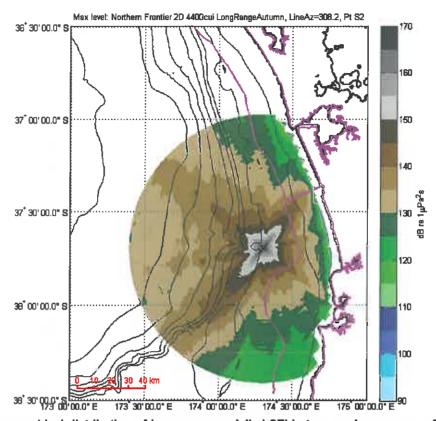


Figure 58: Geographical distribution of long range modelled SEL's to a maximum range of 80 km at S2. Survey line azimuth is 308°T with the West Coast North Island Marine Mammal Sanctuary shown in magenta

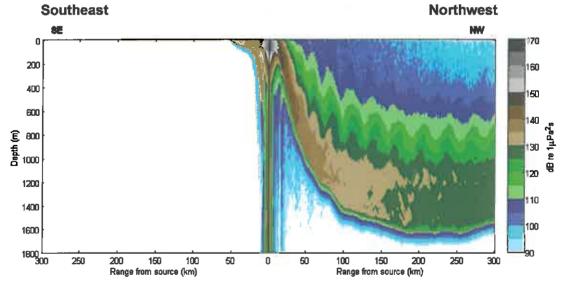


Figure 59: Vertical cross-section through the sound field in the in-line direction (130°T and 310°T), centred on S2. The magenta line is seabed.



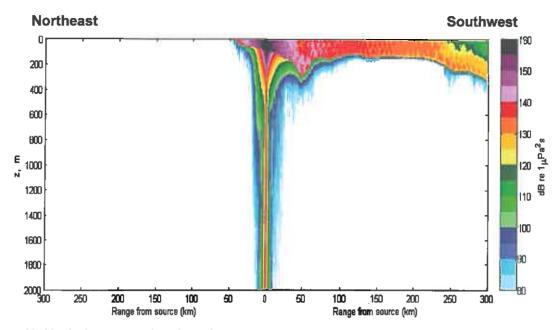


Figure 60: Vertical cross-section through the sound field in the cross-line direction (40°T and 220°T), centred on S2. The magenta line is seabed.

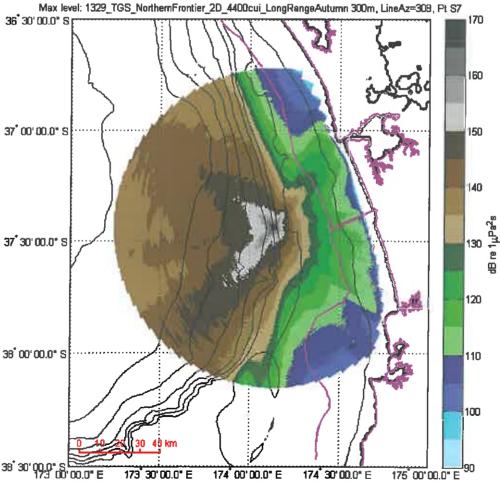


Figure 61: Geographical distribution of long range modelled SEL's to a maximum range of 80 km at S6. Survey line azimuth is 308°T with the West Coast North Island Marine Mammal Sanctuary shown in magenta



5.1.2.2 Behavioural Effects on Marine Mammals and Fauna

5.1.2.2.1 Changes in Abundance or Behaviour of Fish

Any changes in abundance and distribution of fish species will have a wide effect both on their predators (i.e. seabirds, marine mammals, fish etc.) and on fishing activities (both commercial and recreational). Studies on the behavioural impacts of seismic surveys on fish are limited so a combination of empirical knowledge and experimental results will be used here to summarise the potential impacts of the NWF 2D MSS.

Overall, MSS acquisition has been noted to cause both vertical and horizontal displacement in fish away from the acoustic source (McCauley et al., 2000a, Handegard et al., 2013, Colman et al., 2008a, Woodside Petroleum Ltd, 2007). Those fish which have a Pelagic lifestyle (rockfish, cod, haddock, blue whiting) have been seen to dive deeper (McCauley et al., 2000a), 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, 2007, Colman et al., 2008a). In addition to displacement responses, fish may also exhibit behaviours such as alarm responses, a tightening of their school structure and an increased swimming speed (McCauley et al., 2000a, McCauley et al., 2003).

It has long been considered by commercial fishers that MSS's can be disruptive to their fishing operations, and this is a view widely held around the world (McCauley *et al.*, 2000a). Additionally, a number of studies have demonstrated a reduction in catch per unit effort in close proximity to MSS's (Bendell, 2011, Handegard et al., 2013).

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 1μ Pa@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).

Off the Taranaki coastline it was previously thought that pelagic fish, such as tuna, are harder to catch when a MSS was being acquired or if the MSS had been recently completed. However, when WesternGeco (a business segment of Schlumberger) undertook a 3D MSS in January 2013, no effects were observed on the Taranaki gamefish season. In fact, it was the best gamefish season the province has had for six years (see below for catch records from New Plymouth Sportfishing & Underwater Club), with marlin even being hooked up in front of the seismic vessel.

- 2004/05 90 (45 weighed & 50 tagged and released);
- 2005/06 25 (9 weighed & 16 tagged and released);
- 2006/07 10 (6 weighed & 4 tagged and released:
- 2007/08 120 (66 weighed & 54 tagged and released);
- 2008/09 19 (14 weighed & 5 tagged and released);
- 2009/10 30 (13 weighed & 17 tagged and released);
- 2010/11 43 (21 weighed & 22 tagged and released);
- 2011/12 36 (5 weighed & 31 tagged and released); and
- 2012/13 67 (25 weighed & 42 tagged and released).

Based on these findings, it is likely that some fish will undertake avoidance behaviour resulting in the displacement of some fish stocks within the NWF Operational Area that are



close to the acoustic source. Importantly, 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 possible increase in fishing effort if fishing is harder and displacement of predator species/disruption of feeding activities (see <u>Section 5.1.2.2.3</u>).

Fish may undertake avoidance behaviour in parts of the NWF Operational Area due to the noise, resulting in temporary displacement from the area while the NWF 2D MSS is being acquired. The extent of this displacement is likely to fall within the normal geographic range of each particular species (Bendell, 2011); however, given this potential displacement or avoidance for fish stocks to occur, it is considered that the risk to fish stocks and their natural habitat preferences in close proximity to the *Aquila Explorer* within the NWF Operational area is *medium*.

In order to keep impact to a minimum, mitigation measures will be implemented. The NWF 2D 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 (~120-150 days) and soft start procedures will be undertaken to allow any fish in the immediate area to move away from the active source.

Those commercial fishers who use the NWF Operational Area as part of their fishing grounds have been advised of the NWF 2D MSS and will be contacted closer to commencement with further details. TGS have been liaising closely with the commercial fishing industry and will do so for the duration of the NWF 2D MSS (Appendix 2).

5.1.2.2.2 Avoidance and startle responses in marine mammals and other marine megafauna

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.

Marine mammals are widely believed to stay away or avoid operating acoustic sources used during MSS (Thompson *et al.*, 2013b). They have been observed swimming away from an acoustic source with some observed instances of rapid surface swimming and breaching (McCauley et al., 2003, McCauley et al., 1998). 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 (McCauley *et al.*, 2000a). In the McCauley *et al.*, (2003) study, the SEL's which initiated this avoidance response was estimated at $160-170~\mathrm{dB}$ re $1~\mathrm{\mu Pa}$ peak to peak. From the NWF 2D MSS STLM, these sound levels are estimated to be present within ~3 km from the acoustic source (Figure 53).

Harbour porpoises exposed to a 470 in³ 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 SEL's 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.*, 2013a). 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 NWF 2D MSS. It is surmised that the potential implication of this in the NWF Operational Area will be the displacement of animals over a larger distance and for a longer period.



As mentioned above (see <u>Section 4.2.4</u>), both resident and migratory or vagrant species are expected to be encountered within the NWF 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. McCauley *et al* (2003) did not detect any changes in migratory patterns caused by seismic survey and it is believed that this can also be applied to the NWF Operational Area through the adherence to the Code of Conduct and associated mitigation measures.

Similar patterns of avoidance have been observed in other species of megafauna. A study which exposed captive sea turtles to an approaching acoustic source indicated that turtles displayed a general alarm response at ~2 km from the acoustic source with avoidance behaviour estimated to occur at 1 km (McCauley *et al.*, 2000a).

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 travel towards a seismic vessel as it entered shallow waters off Taranaki with an active source to ride the bow waves. 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 vessel 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 desktop study are expected at some stage in 2014.

Despite the noted instances where marine mammals have been attracted to seismic survey vessels, it is considered that acoustic emissions from the NWF 2D MSS have a *medium* risk to marine mammals and megafauna due to potential avoidance and displacement from the NWF Operational Area.

Mitigation measures against this type of impact on marine mammals include the adherence to the Code of Conduct and additional mitigation measures based on the STLM.

Once the NWF 2D MSS is complete, any resonant noise within the NWF Operational Area or surrounding marine environment would diminish allowing animals to return to their preferred habitat.

5.1.2.2.3 Disruption to Feeding Activities

The potential disruption to feeding activities caused by the acoustic emissions of the NWF 2D MSS is linked to the displacement of prey species (see Section 5.1.2.2.1) and the displacement of the predators themselves away from feeding grounds (see Section 5.1.2.2.2). Either scenario leads 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 will potentially be alarmed as the seismic array passes by them causing them to stop feeding (Macduff-Duncan and Davies, 1995). Additionally, the displacement of baitfish (pilchards, saurie, anchovies etc.) will lead to a reduction in the diving activity of birds such as the Australasian gannet.

Similarly, marine mammals could be forced to leave feeding grounds (e.g. large aggregations of krill or fish) as a result of the NWF 2D MSS acoustic emissions. As mentioned earlier (see Section 5.1.2.2.2), 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. There are a number of potential feeding grounds within or surrounding the NWF Operational Area. These include upwellings at the Three Kings Islands; and bathymetric features such as seamounts and ridges which are numerous in the northwestern sector of the NWF



Operational Area (see <u>Section 4.1.3</u> and <u>Section 4.2.4.4.2</u>). Data on the potential offshore feeding grounds is scarce and any sightings recorded during the NWF 2D 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 NWF 2D 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. The survey lines extend for many kilometres through the NWF Operational Area, so the vessel will not be concentrating in any one particular area. Therefore, the potential disruption and disturbance to marine mammals feeding activities by the NWF 2D MSS acoustic source within or in areas adjacent to the NWF 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 additional mitigation measures based on the STLM.

Once the NWF 2D MSS is complete, any resonant noise within the NWF Operational Area or surrounding marine environment would diminish allowing animals to return to their preferred habitat.

5.1.2.2.4 Modification of reproductive behaviour in marine mammals

If there is potential for the acoustic source emissions of the *Aquila Explorer* to cause displacement of marine mammals, it should also be concluded 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 NWF Operational Area the risk of impact on reproductive behaviour is limited to the encounter of 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.

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

5.1.2.2.5 Interference with Acoustic Communication Signals

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 through a MSS emitting sound in the same frequency range as these biological signals could interfere with, or even obscure, sounds emitted by individual animals and potentially lead to significant environmental effects (Dilorio and Clark, 2009, Richardson et al., 1995). Adaptive responses to anthropogenic sound such as changes in vocalisation strength and frequency have been documented in numerous studies (McCauley et al., 2003, McCauley et al., 1998). The common communication and echolocation frequencies of cetaceans that could be observed within the NWF Operational Area are presented in Table 18.



Table 18: 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

As mentioned in <u>Section 3.1</u>, the sound frequencies emitted from seismic acoustic sources are broadband with most of the energy 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 the NWF Operational Area include: southern right whale, pygmy right whale, humpback whale, minke whale, sei whale, Bryde's 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 NWF Operational Area include: rough-toothed dolphin, bottlenose dolphin, spotted dolphin, striped dolphin, long-snouted spinner dolphin, common dolphin, dusky dolphin, southern right whale dolphin, Risso's dolphin, melon-headed whale, pygmy killer whale, false killer whale, killer whale, long finned-pilot whale, sperm whale, Arnoux's bealed 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 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 NWF Operational Area include: dwarf sperm whale, pygmy sperm whale, Maui's dolphin and Hector's dolphin.

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 18.

The low frequency cetaceans (mysticetes) are particularly affected since they have the most overlap with the frequencies of seismic survey acoustic sources (<u>Figure 62</u>).

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 (Dilorio and 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.

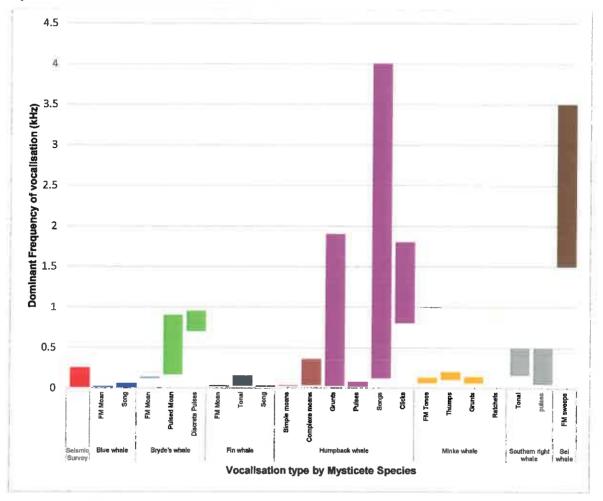


Figure 62: Dominant frequencies of vocalisations produced by mysticete species likely to occur in NWF Operational Area and overlap with MSS acoustic emissions

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 18).

From the reviewed studies and available literature it is considered that the acoustic source emission from the NWF 2D MSS could have a **medium** risk to marine mammal's use of naturally produced acoustic signals.

5.1.2.3 Physiological Effects on Marine Mammals and Fauna

5.1.2.3.1 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, SEL's need to be very high (Richardson et al., 1995) and these are only found close to the acoustic source. The STLM showed that the SEL's for injury criteria as identified in the Code of Conduct are likely to be



at a range of less than 150 m from the source for the modelling location S3 which was derived for a water depth of 300 m.

Elevated SEL's can lead to a threshold shift in hearing, which in most cases is believed to only be temporary, while exposure to an extreme SEL or multiple or prolonged exposure to a loud sound could cause a permanent threshold shift. Studies on beluga whales and dolphins have shown that temporary threshold shift occurred until SEL's were in the order of 225 – 230 dB re 1µPas⁻¹, which for a MSS is within a few tens of metres from the acoustic source (OGP/IAGC, 2004).

Although it has been hypothesised that seismic activities may lead to strandings of cetaceans, no direct correlation has been found. Beaked whales have shown some strong evidence of stranding when exposed to tactical military mid-frequency sonars; however, seismic survey sounds are quite different from sonar operations – in frequency, direction, and duration. To date there has been no conclusive scientific link that has been established between seismic surveys and any marine mammal strandings (www.iagc.org).

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 ALARP during the NWF 2D 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 within range that any physiological effects could occur (see Section 5.1.2.2.2).

Based on the information above, it is considered that the acoustic source emissions during the NWF 2D MSS could have *medium* physiological effects on marine mammals in close proximity to the *Aquila Explorer*.

5.1.2.3.2 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, they are likely to be beyond any harmful range (Macduff-Duncan and Davies, 1995), and 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*.

5.1.2.3.3 Fish

Studies undertaken on fathead minnows (*Pimephales promelus*) have shown that threshold shift in hearing is directly correlated to the frequency and duration of sound exposure (Skolik & 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 NWF 2D MSS is between 2 – 250 Hz, and the sound emissions will only occur every 10-11 seconds during acquisition.

Another study on northern pike (*Esox lucius*), broad whitefish (*Coregonus nasus*) and lake chub (*Couesius plumbeus*) exposed to a 730 in³ acoustic source (significantly smaller than the NWF 2D MSS acoustic source) found varying degrees of threshold shift, but recovery occurred within 24 hours of exposure (Popper *et al.*, 2005).

In 2006, Woodside Energy Ltd applied to the regulator in Australia (Environmental Protection Authority) to undertake the 340 km² Maxima 3D MSS around Scott Reef in Western Australia. Prior to the survey an extensive marine 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 (2,905 in³) to be used in the Maxima MSS. The monitoring work consisted of shallow water fish diversity and abundance, coral monitoring, deep-water fish diversity and abundance, collection of fish samples for pathology studies, 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 this study was that no hearing impacts (temporary or permanent) were found in fish after exposure to the acoustic source and crucially, that there were no long term impacts on fish populations (Woodside Petroleum Ltd, 2007, Colman et al., 2008a).

It has been concluded that during the NWF 2D 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 any lasting physiological effects caused by the acoustic source emission during the NWF 2D MSS on fish species is considered to be *low*.

5.1.2.4 Physiological Effects on Invertebrates

Marine organisms which cannot flee from an approaching seismic vessel and acoustic source (i.e. plankton, fish eggs, some crustaceans, cephalopods and sessile organisms) could be at risk of physiological effects from sound exposure. Relevant literature has been reviewed and summarised below.

5.1.2.4.1 Larvae

Early larval stages of fish and invertebrates generally have a pelagic lifestyle. It is at this stage in 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 (DIR, 2007).

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) after fertilisation to observe the development through the different larval phases.

At completion of the Aguilar de Soto *et al.* (2013) study, 46% of the noise-exposed larvae showed malformations, which were evident as abnormal growth, with localised bulges in the soft body of the larvae, but not in the shell. In the tanks with no noise exposure, no malformations were found in the four control flasks. These results are the first evidence that continual sound exposure can cause growth abnormalities in larvae. It was concluded in the study 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 was 160 dB re 1 μ Pa at 1m, but the particle velocities experienced by the larvae imply far-field pressure levels of 195-200 dB re 1 μ Pa. 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. From the STLM, a SEL of 195-200 dB re 1 μ Pa is confined within 150 m of the acoustic array at the S3 location.



However these results have to be treated with caution when applying them to industry standard MSS's. In the Aguilar de Soto et al. (2013) study, the acoustic source was activated within a small confined tank, 5-15 cm from the larvae at a shotpoint interval of 3 seconds, compared to most MSS's where they have a shotpoint interval of approximately 8-11 seconds. The study was undertaken on larvae that had only been fertilised one hour previously, whereas the NWF Operational Area is located 28 km offshore from the west coast of the North Island at its closest point. So although there is the potential for shellfish larvae to be within the water column, the likelihood that any shellfish larvae have just been fertilised is very low. During acquisition the Aquila Explorer will be continuously moving at 4.5 kts, so any larvae present in the immediate vicinity of the acoustic source will not be exposed to the acoustic sound for the periods that the scallop larvae were exposed to in the Leigh Marine Laboratory. In Aguilar de Soto et al. (2013) it clearly shows there is strong evidence that acoustic sound can cause malformations in larvae; however, the exposure times of larval phases during the NWF 2D MSS will be much less than those in the scallop larval study. It is assumed that the exposure results of Aguilar de Soto et al. (2013) could be applied to other shellfish and fish in early larval developmental stages, but due to the distance offshore, the continual movement of the vessel, the risk to fish and shellfish larvae is considered to be low if they are in close proximity to the acoustic source.

5.1.2.4.2 Benthos

There is currently little information on how marine organisms process and analyse sound, making assessments of the impacts of artificial sound sources in the marine environment difficult (Andre and Kamminga, 2000). Research has shown that the effects of noise produced by a MSS on macroinvertebrates (scallop, sea urchin, mussels, periwinkles, crustaceans, shrimp, gastropods and squid) 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., 2011a, Andre et al., 2011b).

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 μ Pa on mussels, periwinkles and amphipods at distances of 0.5 m or greater. Results showed there was no discernible effects on the mussels or amphipods as a result of the acoustic sound at these close 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 μ Pa 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 of no observed effect was attributed to the absence of gas-filled organs with a rigid exoskeleton. However, a study on the Iceland scallop and sea urchins exposed to an acoustic source (233 dB 1 μ Pa) at a distance of 2 m showed that one of the three scallops exposed had a shell which split and 15% of the spines in the sea urchins fell off when exposed.

From the summary above and based on the fact that the NWF 2D MSS will mostly be conducted in waters greater than 300 m in depth, it is considered that the NWF 2D MSS would have *low* physiological effects on marine benthos.

5.1.2.4.3 Deepwater corals

The potential effects of noise on 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 5.1.2.4.1).

The Woodside Petroleum (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 MSS's can be undertaken in sensitive coral reef environments with no detrimental impact (Colman *et al.*, 2008b).

Based on the Woodside Petroleum (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 within the NWF Operational Area. These corals 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 (Consalvey et al., 2006, Parker et al., 1997).

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 within the NWF Operational Area. As a result, it is considered that the acoustic emissions from the NWF 2D MSS will pose a *low* risk to the deepwater corals.

5.1,2.4.4 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., 2011a, Andre et al., 2011b). Although startle responses have been observed in caged cephalopods exposed to acoustic sources with received SEL's of 174 dB re 1 µPas⁻¹ (McCauley *et al.*, 2000b), studies addressing noise-induced morphological changes in these species have been limited (Andre *et al.*, 2011b).

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, where a sound shadow exists near the water surface of almost 12 dB re 1 μ Pa. 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) which identified the presence of lesions in the statocysts, which are believed to be involved in sound reception and perception. The sound levels received from these sound waves were measured with a calibrated hydrophone within the tanks which showed sound levels of 157 \pm 5 dB re 1 μ Pa, with peak levels at 175 re 1 μ Pa. 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.*, 2011a). Based on the STLM, these peak sound levels can be found within approximately 1.5-2 km from the acoustic source used for the NWF 2D MSS (Figure 53 & Figure 54).

Both squid and octopus are present in waters surrounding the NWF Operational Area. Octopus generally live a cryptic lifestyle around reef structures and generally closer to shore in waters shallower than 200 m. Squid occur in the pelagic waters within the NWF Operational Area (see Section 4.2.3). However, the majority of commercially caught squid within NZ waters is caught off the bottom of the South Island and Auckland Islands between January and May. 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.



The chances of octopus being within 1.5-2 km from the acoustic source is low given the NWF 2D MSS will mostly be conducted in water depths of greater than 300 m and the closest survey line to land is approximately 40 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 on the west coast North Island of NZ.

Based on the information detailed above, the risk of the acoustic emissions of the NWF 2D MSS to cephalopod species is considered to be *low*.

5.1.3 Solid and Liquid Wastes

During the NWF 2D 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.

5.1.3.1 Generation of Sewage and Greywater

The liquid wastes that will be generated during the NWF 2D MSS will include sewage and greywater (wastewater from washrooms, the galley and laundry). The *Aquila Explorer* and *Ocean Pioneer* have onboard sewage treatment plants which ensure a high level of treatment before the waste is discharged. All vessels involved in the NWF 2D MSS have an International Sewage Pollution Prevention Certificate (ISPPC).

As a result of the high level of treatment the sewage generated by the vessels involved in the NWF 2D 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 after it has been comminuted and can pass through a 25 mm screen. Comminuted waste can be discharged beyond 3 Nm from shore and 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, including hazardous returned to shore will be disposed of in strict adherence to local waste management requirements with all chain of custody records retained by TGS.

As a result of these operating procedures in place 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 is generally derived from the bilges. The *Aquila Explorer* has a bilge water treatment plant that achieves a discharge that is superior to NZ and MARPOL requirements of 15 ppm.

All vessels involved in the NWF 2D MSS have approved International Oil Pollution Prevention Certificates (IOPPC) 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 *Aquila Explorer'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 *Aquila Explorer* has an International Air Pollution Prevention Certificate (IAPPC) which ensures that all engines and equipment are regularly serviced and maintained.

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 NWF Operational Area and the anticipated low level of emissions, the environmental risk arising from the NWF 2D 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, 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 streamer could result from snagging with floating debris; or rupture from abrasions, shark bites or other vessels crossing the streamer.

The streamer to be used in the NWF 2D MSS is largely a solid streamer; however, there is a short section which is likely to be gel-filled. The gel-filled sections of streamer along with the solid sections are unlikely to result in an environmental effect on the marine environment if it was to break or be severed. The streamer is negatively buoyant and requires movement to maintain depth so if the streamer was severed it would start sinking. The streamer has 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 NWF 2D MSS will be undertaken by experienced personnel. Seabird Exploration is a very experienced seismic contractor with a good track record of operating in NZ waters under the Code of Conduct and to date has been incident free. As a result of this experience in NZ waters and the type of streamer to be used during the NWF 2D MSS, if the streamer was severed or lost the environmental risk would be *low*.

5.2.2 Fuel or Oil Spills

The potential for a fuel or oil spill during the NWF 2D MSS could arise from; leaking equipment or storage containers or hull/fuel tank failure due to a collision or sinking. The largest potential for an environmental effect would result from a hull/fuel tank failure as the other potential for spills would be generally contained on the vessel. If a spill did occur, the effects on the environment would depend on the size of the spill and the location in proximity to sensitive environments. Although control measures are in place to prevent a spill that would have an adverse effect on the marine environment.

If a spill from the *Aquila Explorer's* fuel tank did occur, the maximum possible spill if the fuel tanks were full would be 1,254 m³ of marine gas-oil. 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 the potential for a spill is unlikely to occur.

All vessels involved in the NWF 2D MSS have an approved and certified SOPEP and IOPPC 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 *Aquila Explorer* has a HSE Management Plan and Emergency Response Plan which would be used in the event of an emergency, including fuel spills.

If a spill was to occur during the NWF 2D MSS the spill response would be undertaken in accordance to the *Aquila Explorer's* SOPEP. MNZ would be notified as required within the Aquila Explorer's Emergency Response Plan. If the spill could not be contained on the vessel, MNZ would most likely take responsibility, dependent on the scale of spill or location (i.e. in the CMA or EEZ).

However, due to the safety, environmental and maritime requirements that will be implemented for the NWF 2D 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 *Aquila Explorer* was at sea, the biggest threat to the environmental would be the vessel reaching the sea floor and the release of any hazardous substances, fuel, oil or lubricants. However, this is very unlikely as the risks are mitigated through the presence of a support vessel at all times and adherence to the COLREGS. As a result, the risk of a vessel collision or sinking is considered to be *low*.

5.3 Mitigation Measures

TGS 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 (Department of Conservation (DOC), 2013). TGS will also implement mitigation measures over and above the Code of Conduct for the NWF 2D MSS. While undertaking the NWF 2D MSS, if there are any instances of non-compliance to the Code of Conduct and the mitigation measures identified below, the MMO's will notify the Director-General of Department of Conservation immediately.

The operational procedures that TGS will follow will be detailed in the MMMP (<u>Appendix 4</u>) and circulated among the MMO's 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 where a number of MSS's were acquired 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 a review of the 2012 Code of Conduct before the next MSS season (2013 – 2014 summer period). For the NWF 2D MSS the requisite mitigation measures specific to a Level 1 MSS are identified in Section 2.3.2. However, TGS will implement additional mitigation measures and these are discussed in Section 5.3.2.

5.3.2 Additional Mitigation Measures for the NWF 2D MSS

5.3.2.1 Sound Transmission Loss Modelling

As discussed in <u>Section 5.1.2.1</u> STLM has been undertaken to predict SEL's at various distances from the *Aquila Explorer*; with the modelling based on the specific configuration of



the acoustic source to be used for the NWF 2D MSS and the environmental conditions (i.e. bathymetry, substrate and underlying geology) of the NWF 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 NWF Survey Area was also amended following the STLM results. 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 1µPa²-s SEL) and injury criteria (186 dB re 1µPa²-s SEL) could be expected. Even though the NWF Survey Area is mostly located beyond the AEI, the original NWF Survey Area did encroach into the AEI. However, the STLM showed that the SEL's were higher than the behaviour and injury criteria thresholds within the Code of Conduct in the shallowest part of the Survey Area and as a result the NWF Survey Area was amended so that the inshore boundary of the NWF Survey Area is mostly bound by the 300 m contour, apart from the southeast corner where the well ties are required.

The STLM for the NWF 2D MSS showed that compliance will be achieved with the Code of Conduct criteria in all waters of a depth above 300 m utilising the standard mitigation zones (see Section 5.1.2.1). For the southeast corner of the NWF Operational Area, where the well ties will be undertaken into water depths of 105 m, the mitigation zone will be increased to 2 km for Species of Concern with or without calf, and to 250 m for other marine mammals when the vessel enters the increased mitigation area shown within Figure 56 and in water depths of less than 300 m (Section 5.1.2.1.2).

As per the requirements in Appendix 1 of the Code of Conduct, the STLM will be validated during the NWF 2D MSS and the results will be provided to DOC. At the start of seismic operations, a vessel self-noise assessment will also be undertaken by the PAM Operators and will be provided to DOC.

The STLM validation will be undertaken by the *Aquila Explorer*'s Chief Field Geologist and the lead MMO onboard the *Aquila Explorer*. To complete this validation, SEL's (dB re 1µPa) will be recorded by receivers in the streamer located at four different offsets from the acoustic source; 200 m, 1,000 m, 1,500 m and 2,000 m. The frequency range measured through the hydrophones will be across a bandwidth of 0-200 hz as this is tuned to the same bandwidth as the frequencies emitted by the source. Therefore, any sound levels above 200 hz are minimal. These recordings will take place within the NWF Operational Area and will record SEL's across different depth measurements within the NWF Operational Area, as SEL's are likely to decrease in the deeper waters (Koessler and Duncan, 2014a). A heading will be selected along one of the track lines and the test sequence will be performed along this line. In order to confirm and provide a reference to the first suite of results, another test sequence will be performed before the end of the MSS, most likely on the opposite heading.

5.3.2.2 Additional marine mammal observations outside NWF Operational Area

The Aquila Explorer will travel to the NWF Operational Area from Port Taranaki on mobilisation and demobilisation, as well as for crew changes every five weeks. On transit to and from the NWF 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 NWF Operational Area will be recorded in the 'Off Survey' forms developed by DOC.

5.3.2.3 Necropsy will be undertaken on any stranded marine mammals

If any marine mammals are stranded or washed ashore during the NWF 2D MSS inshore of the NWF Operational Area along the coastline from Cape Reinga to New Plymouth, TGS would engage Massey University to undertake a necropsy to try and determine the cause of death and whether it was a result of any pressure-related or auditory injuries. DOC will be responsible for all aspects of undertaking the necropsy and coordination with pathologists at



Massey University; however, TGS will cover the associated costs. TGS will meet these costs for any necropsies required during the NWF 2D MSS and for a period of two weeks after the acquisition of the last source-point.

5.3.2.4 Notification of any marine mammal carcass observed at sea

If a marine mammal carcass is observed at sea during the NWF 2D 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 occur within the NWF Operational Area contributing to an increased level of underwater noise. The cumulative effect of shipping and seismic survey noise was investigated in the Dilorio & Clark (2009) study and it was concluded that shipping noise did not account for any changes in the acoustic behaviour of blue whales (Dilorio and Clark, 2009). Hence, noise from shipping traffic has not been considered in this cumulative effects assessment.

There is the potential that other MSSs may take place off the west coast of the North Island concurrently to the NWF 2D MSS. However, the size of the operational areas and the distance between the surveys will not result in significant noise effects from the two sources combining. Both operators cannot have interference from other seismic surveys so the acquisition and timing/location within the respective operational areas will be well managed.

Therefore, with good communication, efficient management, and mitigation measures in place; the potential cumulative effects on marine mammals, marine fauna or the marine environment from the NWF 2D 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 NWF 2D MSS as identified in this MMIA are summarised in <u>Table 19</u>.



Table 19: NW

Aspeci or Source	Potential Firmment and Effect	Lifethood of Occurrence	Consequence of Occurrence	Proposed Mingation Wearrack to Avoid, Pernedy or inhiquite Environmental Effects	Rink Calapory Renking
. CONTROL OF THE SE	STANSON WINN SASON ME	THE RESIDENCE OF STREET	Planderwise	HANGE TO BE UNDERSTONE THE OFFICE OF THE SERVICE OF THE	Company of the contract of the
	Interference with the fishing community and marine traffic.	Passible	Minor	24/7 operations to minimise overall duration of MSS. Compliance with COLREGS. Support vessel present at all times. Notification to commercial fishing companies and representatives. Notification to sportifishing clubs. Notification to sportifishing clubs.	Midsen
	Interference with marine archaeology, cultural heritage or submarine infrastructure.	Unlikely	Neg)igible	Streamer has SRD's. Comptience with COLREGS. Support vessel present at all times.	11-
Physical presence of Aquile Explorer, acoustic arrey and	Changes in seabird behaviour.	Negligible	Negligible	No mitigation options available, MMOs will record any seabled strikes with the vessel that are witnessed.	400
acousic alley end	Introduction of marine posts or invasive species.	Negligible	Minor	Recent dry-dock of Aquila Explorer (November 2013) and new entifculing paint applied. Adherence to Import Health Standard for ballest water exchange. Adherence to Craft Risk Management Strategy for biofouling.	-
	Interaction with marine mammals.	Possible	Minar	Compliance with the Cociu of Conduct and miligration zones. Two MMOs and two PAM operators will be observing for merine mammels. 24 hours/day. Pre-survey observations, soft-start and deleyed start/shut down procedures will be followed for duration of NWF 2D MSS. STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria.	Weditin
Acoustic sound source emissions — sehavioural effects	Changes in abundance or behaviour of fish	Possible	Minor	24/7 aperations to minimise overall duration of NWF 2D MSS.	Medium
	Avoidance and startle responses in marine marinnals and other marine megafauna	Passible	Minor	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammels 24 hours/day. Pre-survey observations, soft-start and deleyed start/shut down procedures will be followed for the duration of NWF 2D MSS. STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury oritaria. Survey Area located beyond the AEI (except the lines in southeast).	Medium
	Disruption to feeding activities.	Possible	Minor	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammals 24 hoursday. Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of NWF 2D MSS. STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. Survey Area located beyond the AEI (except to lines in southeast).	Месікап

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Aspect or Source	3 remail Environmental Erico	Lahekinoovi of Occurrence	Connequency of Orountaice	Annotes i Mingelon Measures to Avoid, Remedy of Hillingin Environmental artisets	Prsk Calegor, Rauking
	Disruption of reproductive behaviour in marine mammats	Unii kely	Minor	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammals 24 hourskips. Pre-survey observations, soft-start and delay ad start/shut down procedures will be followed for duration of NWF 2D MSS. STLM to validate mitigation zones used against sound exposure thresholds for beheviour criteria and layly orderia. Survey Area located beyond the AEI (except tile fines in southeast).	(1995)
	Interference with accusio communication signals.	Possible	Minor	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammals 24 hoursiday. Pre-survey observations, soft-start and deleyed start/shut down procedures will be followed for duration of NWF 2D MSS. STLM to validate mitigation zones used against sound exposure thresholds for behaviour ortheria and injury ortheria. Survey Area located beyond the AEI (except tile lines in southsest).	Medium
Acoustic sound source emissions — physiological effects	Physiological effects on marine manmals	Possible	Minar	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammals 24 hours/day. Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of MSS. STLM to validate mitigation zones used against sound exposure thresholds for behaviour criteria and injury criteria. Survey Area located beyond the AEI (except tile lines in southeast).	Meawn
	Physiological effects on seabirds	Unlikely	Negligible	Vessel is underway for the duration of the NWF 2D MS2. 24/7 operations to minimise overall duration of NWF 2D MSS.	Liters.
	Physiological effects on flah	Unlikely	Minor	Vessel is underway for the duration of the NWF 2D MSS. 24/7 operations to minimise overall duration of NWF 2D MSS.	I/E
Accustic sound source emissions — physiological effects on invertebrates	Physiological efforts on larvae	Unlikely	Minar	Vessel is underway for the duration of the MWF 2D MSS. 24/7 operations to minimise overall duration of NWF 2D MSS. Survey Area is located a long way from shore.	16
	Physiological effects on benthos	Unlikely	Minor	Vessel is underway for the duration of the NWF 2D MSS. 24/7 operations to minimise overall duration of NWF 2D MSS. Survey area is located in deep water.	10.00
	Physiological effects on deepwater corals	Unlikely	Negligible	Vessel is underway for the duration of the NWF 2D MSS. 24/7 operations to minimise overall duration of NWF 2D MSS.	162
	Physiological effects on cephalopods	Unlikely	Minor	Vessel is underway for the duration of the NWF 2D MSS. 24/7 operations to minimise overall duration of NWF 2D MSS.	10-
Solid and liquid wastes.	Generation of sewage and greywater.	Possible	Negligible	On-board sewage treatment plant, Adherence to MARPOL Approved ISPPC,	WHI.

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Sepecial Source	Powerful Environmental Effect	Likelihord of Ocumenca	Consequence of Occurrence	Projugaci Magazin Massaurus to fivoid, Remedy or Margine Environmental Effects	risk Caregory Ranking
	Generation of galley waste and garbage.	Pasalble	Negligible	Only biodegradable and comminuted waste will be discharged. Adherence to MARPOL Annex V.	Levi
	Generation of oily waters.	Unitikely	Negligible	Adherence to MARPOL Oily-water separators. Approved IOPPC. Approved SOPEP.	04:
Atmospheric emissions.	Atmospheric emissions.	Unlikely	Negligible	Approved IAPPC. Regular maintenance of motors, equipment and generators.	100
Cumulative Effects	Cumulative sound exposure on marine mammals from two seismic surveys	Unlikety	Negligible	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for marine mammals. 24 hoursidey. Pre-survey observations, soft-start and delayed start/shut down procedures will be followed for duration of MNP 2D MSS. If another survey is to be acquired, the vessels would communicate so that the MSS were acquired as far apart as possible to minimize disturbance to marine environment and also prevent interference with the received signals from each source.	#
			Doctoroid covers		
Streamer break or loss.	Water or seabed impact.	Unlikely	Negligible	Streamer has SRD's fitted. Support vessel present at all times.	
Fuel or oil spills.	Water and coastal impact.	Unlikely	Neg∏gible	Compilance with COLREGS. Approved SOPEP. Approved IOPPC.	16.
Vessel calision or ainking.	Water and coastal impact.	Unlikely	Minor	24/7 operations to minimise duration of survey. Compliance with COLREGS. Support vessel present at all times. Notice to Mariners issued and coastal navigation warmings broadcast on Maritime Radio. All users have been advised of the NWF 2D MSS operation.	New T

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6 Environmental Management Plan

The management of environmental risks associated with TGS's activities is integral to their business decision-making processes. Potential environmental risks/hazards are identified during planning stages and throughout operations, and their associated risks are assessed and managed via a structured management system and in conjunction with the Management System of the selected seismic contractor, in this case Seabird Exploration. These mechanisms ensure that TGS's high environmental standards are maintained, the commitments specified in this MMIA are achieved and that any unforeseen aspects of the proposed NWF 2D MSS are detected and addressed.

The Environmental Management Plan (EMP) highlights the key environmental objectives, the proposed actions that will be undertaken to control the environmental parameters identified and lists the relevant legislation and protocols that will be applied.

The mitigation measures for the NWF 2D MSS will be implemented to eliminate, offset, or reduce any identified environmental effects to ALARP.

The Aquila Explorer 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 NWF 2D MSS is provided in <u>Table 20</u> and will be undertaken in conjunction with the MMMP (Appendix 4).

The NWF 2D MSS will be conducted in accordance to (but not limited to) the Code of Conduct, all relevant Maritime regulations, Marine Protection Rules, Environmental Best Practice Guidelines for the Offshore Petroleum Industry (MfE, 2006) and the Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 2013 (Mateparae, 2013). As a result of compliance with the Code of Conduct, if any marine mammals are observed within the relevant mitigation zones, the four qualified observers onboard the *Aquila Explorer* have the authority to delay or shut down an active seismic array.



Table 20: NWF 2D 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, Continuous.	24/7 operation to minimise NWF 2D MSS duration. Information provided to fishing authorities, fishing and boating clubs. Support boat investigation and Notice to Mariners issued.	COLREGS. International best practice.
Minimise introduction of marine pests.	Hull fouling. Ballast water discharge.	Continuous.	Antifouling systems in place (recently slipped in November 2013). Adherence to ballast water regulation: Regular maintenance undertaken.	International best practice. Import Health Standard for Shipe Ballast Water from All Countries (Blosecurity Act 1993). 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 accustic source is active.	Continuous observation 24 hours per day by four qualified observers. Use of PAM 24/7.	Compliance with Code of Conduct and Section 5.3. 24/7 operation to minimise the NWF 2D MSS duration. Presence of two qualified MMO's and two qualified PAM operators (PAM used 24/7). Pre-start observations, soft start and delay start/shut down procedures.	The Code of Conduct. Marine Mammals Protection Act 1978 & Marine Mammals Protection Regulations 1992.
	Liquid wastes.	Continuous.	Discharge to sea in accordance with MARPOL and NZ regulations.	MARPOL 73/78. NZ Maritime Transport Act 1994.
Minimise effects on sea water quality.	Oil and other wεste.	Continuous.	Disposed at an approved shore reception facility in compliance with legal procedures and maintain a weste disposal log. Approved SOPEP and IOPPC.	MARPOL 73/78. NZ Maritime Transport Act 1994.
	Blo-degradable wastes.	Continuous.	Can be discharged overboard beyond 12 Nm from the coastline or 3 Nm if comminuted.	MARPOL 73/78. 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. NZ Maritime Transport Act 1994.
Oute Waste Hallagement.	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. NZ Maritime Transport Act 1994,
Minimise effects on air quality.	Atmospheric emissions.	Continuous.	Proper maintenance of equipment and generators. Approved IAPPC and regular monitoring of fuel consumption.	Best practice.
Minimise accidental events.	Streamer break or loss. Collisions. Fuel/oil spills.	Continuous.	24/7 operations to minimise survey duration. Hull is built to loe Class rating. Streamer has SRD's fitted. COLREGS and presence of a support vessel. Approved SOPEP in place.	Best Practice. COLREGS.

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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.

TGS will comply with the Code of Conduct, NZ Maritime Rules, NZ Marine Protection rules, TGS's internal HSE documents and implement international best practice to ensure that during the acquisition of the NWF 2D MSS the effects on marine mammals, marine fauna, the marine environment or any personnel are reduced to ALARP.

As well as adhering to the Code of Conduct, TGS 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 as a result of adherence to the mitigation zones as well most of the NWF Survey Area being limited to the 300 m contour line apart from the well ties, the NWF 2D MSS should not result in any injury to marine mammals. TGS will have two independent and suitably qualified MMO's and two independent and suitably qualified PAM operators on board the *Aquila Explorer*, 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 Aquila Explorer is a specialised MSS vessel with a proven (incident free) track record operating in NZ waters. The Aquila Explorer 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 NWF 2D 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 NWF 2D 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.

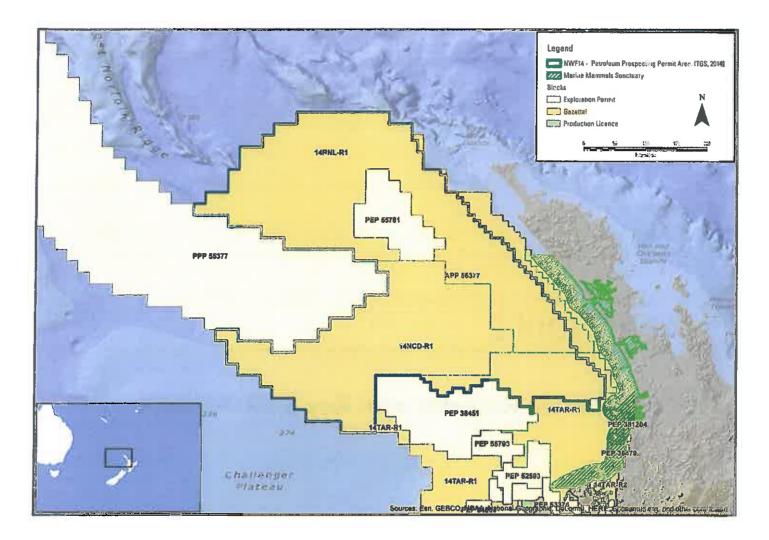
Number	Title	
1	NWF 2D MSS Information Sheet	
2	Consultation Register with Key Stakeholders	
3	Technical Details of the PAM system	
4	Marine Mammal Mitigation Plan for the NWF 2D MSS	
5	Sound Transmission Loss Modelling	
6	NWF 2D MSS Environmental Risk Assessment Summary	



APPENDIX 1

NWF 2D MSS Information Sheet





Northland Multi-Client 2D Seismic Survey 2014

Non-Exclusive PPP56377

TGS' proposed multi-client 2D seismic survey will be located within Petroleum Prospecting Permit 56377 in the Reinga, Northland and Taranaki Basins, offshore northwest New Zealand.

At the closest point, the survey area is situated more than 30 km from the West Coast of the North Island.

The survey will be acquired using the Aquila Explorer vessel. A 10 km long streamer will be towed behind the vessel, just below the water surface, at a depth of 8-30 m. The end of the streamer is marked with a tail buoy fitted with flashing lights and a radar reflector. Behind the Aquila Explorer an acoustic source will release a sound wave from compressed air which travels down through the water column into the underlying rock. The streamer has hydrophones positioned along the inside to pick up and record sound that is reflected by layers in the rock. These recordings can then be processed to provide an image of the subsurface geology directly below the acoustic source.

The survey is due to commence early December 2014 and will continue through to the end of April 2015.

Please contact Dan Govier (Environmental and Stakeholder Consultant) via email at dan@eosltd.co.nz should you have any questions concerning the survey.

For more information, contact TGS at:

AUS

Tel: +61 8 9480 0000 Email: info@tgs.com

See the energy at TGS.com



Aquila Explorer





APPENDIX 2

Consultation Register with Key Stakeholders



TGS NWF 2D MC Consultation 2014

In all meetings, post introductions TGS/EOS provided an overview of TGS and the proposed survey details. This included information on the permit, timing of the survey, vessel, streamer length, survey area, sound modelling and regulatory requirements. Also included details on the additional mitigation measures TGS have taken with refinement of the survey area.

Te Runanga o Ngati Mutunga. 30th June 2014

Ngati Mutunga had not received an information pack from NZPAM in regards to the PPP application.

There were no concerns around the process or the survey and Ngati Mutunga wished TGS well and thanked us for engaging with them.

Department of Conservation - Taranaki Area Office. 30th June 2014

The request was made that any Maui's dolphins sightings be reported in a timely manner.

Necropsies for any strandings were also discussed and boundaries for this were considered a challenge. TGS undertook to have further conversations with Department of Conservation head office.

DOC were reassured that fishing interests had received notification of the survey.

Ngati Tama. 30th June 2014

Representatives weren't in a position to discuss the survey. It was agreed further information would be distributed electronically and an information sheet was provided.

Port Taranaki - 1st July 2014

Bunkering and crew changes were discussed. Representatives were interested in the vessel as part of their planning for the upcoming summer season. It was noted that the survey is in the main shipping route from those vessels coming around the top of the north island to Port Taranaki.

DOC - Hamilton Office

Necropsies on stranded mammals were discussed. It was noted that the remoteness of coastal beaches presents a problem for necropsy due to the speed of decomposition.

DOC also noted the information on marine mammals in the survey area is quite limited generally.

Ngati Mahuta - Kawhia Harbour - 2nd July 2014

Concerns were raised about the potential for vessels effecting shellfish beds. Details of the survey proximity to the harbour and the speed of the vessel were explained.

It was clarified that TGS are not drilling.

Tainui Kawhia Incorporation - Ngati Hikairo - 2nd July 2014

It was noted there is quite a bit of opposition to the oil and gas industry and suggested there is a general lack of understanding and misinformation.

A list of questions was provided to TGS for answering. Representatives also thought TGS were drilling. The significance of Kawhia as a special place was discussed and the key issue

was lwi not wanting to see oil on beaches. These questions and answers are in the emails included in this Appendix.

TGS were invited to attend a Hui to experience the Maori culture and to explain the surveying process in more detail. However, due to timing constraints this did not occur.

Taranaki lwi Trust and Te Atiawa

TGS were asked to provide electronic information in lieu of a meeting. The information sheet was sent out as requested.

Tainui lwi

Representatives were not available to meet with TGS but expressed appreciation that TGS were talking with the local iwi and the harbours.

Tainui Hapu environmental Management Committee - Raglan

TGS were asked to provide electronic information in lieu of a meeting.

Maniapoto Trust Board

Information was provided to this trust board as part of the early engagement process, but a lead in time of two months was considered necessary to consider the proposal before a meeting could be held. A meeting was held in September with details provided below.

Waahi Whanui Trust

Representatives were satisfied that they did not need to meet with TGS.

Nga Hapu o Ngaruahine lwi

Representatives were satisfied that they did not need to meet with TGS but would like to be kept informed electronically.

The Proprietors of Taharoa C Block were unable to meet with TGS

No responses were gained from the following, despite two separate emails:

- Moana Rahui o Aotea
- Ngati Paoa Trust Board
- Nga Ruahine iwi Authority

Sanford Limited 11th August 2014

The fisheries assessment prepared by MPI was provided to Sanfords.

The main issue for Sanfords is the timing of the survey – i.e. during the main (summer) fishing season. TGS responded with examples of Tuna fisheries experiencing increased catches in the Great Australian Bight and other literature studies. Sanfords noted these examples are not related to NZ species specifically.

Other issues identified by Sanfords included trawl catches, mainly for inshore fisheries. The northern inshore area is considered to be the most sensitive area for trevally and snapper fisheries over summer.

Sanfords requested an adaptive management approach with triggers if catch rates decline. It was stated that Sanfords would see TGS in court if catch was compromised.

TGS expressed a willingness to work with the fishing industry regarding survey line acquisition and will provide a summary to the company 2-3 days in advance for where the vessel will be. As a result TGS and Sanfords are working close together leading up and during the survey with weekly discussions and updates regularly provided. This approach appears to be a good way forward for all involved.

Sanfords offered to be the conduit between other fishing companies and TGS.

Te Runanga Nui o Te Aupouri – 13th August 2014

In response to confusion, TGS clarified the 2 consultation processes running – the TGS MMIA process and the NZP&M block offer process.

Questions asked and matters discussed were:

- the likelihood of an MMO seeing marine mammal(s),
- soft starts,
- TGS's weekly reporting to DoC.
- mitigation measures if marine mammals are present in high numbers.
- the impact of pressure and sound waves on the marine environment.

The overall position was that Te Runanga Nui o Te Aupouri have limited concern with seismic and are more concerned about drilling and possible exploration. The tension between development and the use of petroleum based products was discussed.

It was also noted that it can be argued that seismic decreases the risk when compared to random drilling, or drilling with limited information.

Nga Hapu o Ahipara, Te Oneroa a Tohe, Ngati Kuri Trust Board - 13th August 2014

The significance of Cape Reinga was presented to TGS, specifically the sacredness of the area. It was further explained that oil is a source of conflict internationally due to the lack of consideration of the culture of the people of the land.

In addition to the usual explanation of TGS and the process further detail was given on mitigation zones, MMO's and PAM. Long range sound modelling, and soft start and shut down were discussed at length.

The purpose of the survey was questioned. Whale migration was discussed, with lead representatives stating that whales migrate through the area in summer. Normal whale migration patterns were discussed. TGS explained about ceasing operations if whales are present.

Confusion around the terminology of MMIA and EIA was evident. Specifications of the hydrophones was discussed, as was the availability of information to whanau an hapū. TGS were asked if they had carried out tests on every species in the area.

Several interjections were made in Te Reo Maori. The discussion then moved to questions for TGS about whether they are aware of the Treaty of Waitangi and whether they are familiar with the concepts of tapu and sacred.

The conversation moved out of scope of the MMIA and turned to topics including:

- Cultural knowledge vs scientific information
- The spirit of the sea
- The three fundamental principles of life (sky, land and living beings)

- The clubbing of a dying seal that morning, based on DoC not being available
- The government has been corrupt in dealing with Treaty claims.

Closing comments from lwi were that seismic surveying is starting a chain of events the people do not want to happen. Drilling was referenced and described as foreigners stealing from Maori.

Parting comments from meeting facilitators referenced strong objections. Representatives expressed to TGS they will oppose TGS on the beaches and at sea and talked about blowing up TGS's boats, going to jail and dying for the cause.

Ngati Wai Trust - 14th August 2014

Key issues outlined were around pelagic fisheries and longlining. Most interests of Ngati Wai trust are deepwater trawl.

Confusion around block allocation and numbers was discussed with TGS clarifying how lots are defined.

lwi expressed the importance of being kept informed as the data is collected and gave positive feedback around sitting down and understanding what is being proposed. Representatives requested all of the Trust being across future engagements.

Te Uri o Hau Settlement Trust – 14th August 2014

Questions were asked around the coverage of the survey area, refinements to the area and how MMO's are appointed. The distance between the survey area and the marine mammal sanctuary was also discussed, as was the speed of the vessel.

"Maori and Mining" document was referenced. Representatives said a process map or document would be useful to assist in understanding the process.

Further questions were asked around mining on tectonic plates and the location of petroleum deposits and reserves. Block numbers (and what they mean) was talked about, as was the timeline between seismic and drilling.

Te Runanga o Ngati Whatua - 14th August 2014

Questions were asked about the various blocks on the survey map. Topical issues identified and discussed further were:

- Deepwater fishing assets
- Juvenille snapper (inshore Kaipara)
- Maui's dolphin
- Drilling in an area of high biomass

Iwi indicated support for growth and development, but noted the assessment of impact needs to be considered early in the process. Engagement with other fishing interests was questioned, and questions were asked around where the vessel will be berthed.

Te Roroa Whatu Ora Trust - 15th August 2014, Waipoua Forest

Representatives had questions about the MMIA and Block offer processes underway and TGS explained the difference. Te Roroa Whatu Ora Trust didn't recall seeing or reading any information from NZP&M.

Kev concerns raised were:

- Timeframe for the permit
- · Who instructs TGS to conduct the survey
- Information flow to tribes
- · Confidentiality of data once it is acquired

Iwi noted that it is difficult to manage the understanding of the community and there is a need for easy to understand information. The "Oil and Gas claim to the Waitangi Tribunal" was referenced. It was also noted that oil companies would face a difficult time in future.

Ngati Rehua - Ngatiwai Ki Aotea Trust - 25th August 2014

A phone call was held with the chief executive and were happy to receive information electronically due, which was provided.

Maniapoto Maori Trust Board 4th September 2014

Questions were asked regarding effects on fish, crayfish, marine mammals, migrating eels and Measures that will be implemented to minimise disruption were explained by TGS.

MMO training courses were discussed.

TGS committed to providing a copy of the complete MMIA to the Trust Board.

A recommendation was also made to contact the coastal fisheries forum (Nga Hapu o Te Uru).

Ngati Te Ata Claims Support Whanau Trust & Ngati Paoa Trust Board – 8th September 2014

No one showed up for the meeting. Subsequent emails received no replies.

Ngati Tamaoho Trust - 8th September 2014

Concerns were raised around the noise impacts of surveying.

Representatives noted that the survey is the mechanics towards drilling, which they do not agree with.

The coastline being taonga and the sensitivity of the area to Maui's dolphins were discussed. Conversations with the Green Party were also referenced. The Trust reinforces they are against anyone making commercial gains from oil and gas.

Te Kawerau lwi Tribal Authority - 9th September 2014

Representatives stated they have interests in the survey area and hold extensive knowledge of the area that the government does not. A number of concerns were raised about the role of the government in the process.

It was also stated the Te Kawerau want to speak to people who have an understanding of tikanga and the sensitivities of Maori concept on land and sea. TGS were invited back for another engagement at a cultural level and asked to bring along an expert in Maori culture that can talk to representatives at the right level.

Key interests in the ocean revolve around the taniwha and the relationship with whales, sharks and stingrays.

Sanford Limited - 9th September 2014

This meeting was a follow up from the August meeting.

Main concerns discussed were the impact of the survey on tuna. The tuna season is similar to the duration of the survey and there are concerns this will impact on catch.

TGS discussed the possibility of flexibility to work in certain areas to minimise disruption.

It was agreed there would be one representative for all four companies (Sanford's, Talleys, Pelco and AFL).

Information flow to fishing interests during the survey period were discussed. A 3 day look ahead and a 30 day preference were discussed, with a 7-10 day plan agreed as being most effective.

Representatives expressed the need for TGS to be responsive to their concerns.

Research on the biomass of tuna was talked about. NIWA and MPI are surveying this and there is a desire to make sure the survey doesn't skew the results at all.

Sanfords requested bathymetry data following the survey. Sea surface temperature and salinity data was also offered. An electronic version of the survey will be provided to Sanfords.

Nga Maunga Whakahii o Kaipara Development Trust 22nd September 2014

Met with the board members to discuss the proposed survey. It was made clear that they are strongly opposed to exploration and do not want any drilling off the Kaipara given the importance of the Kaipara Harbour to everyone.

Asked some questions around how engagement with iwi is ranked and stated they will be discussing with DOC as to how engagement with iwi for offshore exploration is undertaken and what importance it is given.

The trust are currently waiting for a customary claim to commence and are waiting to begin negotiations with the crown.

Requested that they get a copy of the MMO report following the survey and would like to work with the scientists if there are any marine mammal strandings within their rohe during the survey. TGS will provide a copy of the MMO report to the Nga Maunga Whakahii o Kaipara Development Trust.

Independent Maori Statutory Board - 23rd September 2014

The purpose of the development Independent Maori Statutory Board was explained to TGS. Was interested to learn about the seismic programme and the regulatory process.

Provided a summary that during consultation it needs to be made clear that there is good jobs for young iwi members going through school and university within the industry. It needs to be made clear that it is a very long time frame from seismic to any production wells so now is the time that iwi should be starting to ensure they have their people coming into this

industry. This way the industry will provide involvement of iwi in the process as well rather than just being involved through consultation.

It was noted that most of the iwi settlements are with primary industries, i.e. fishing, farming and forestry, all of which require oil and gas. Therefore to keep these assets producing, everyone needs a supply of oil and gas as well as the technologies which are derived from hydrocarbons.

Te Kawerau lwi Tribal Authority - 23rd September 2014

This was the second meeting with Te Kawerau Iwi Tribal Authority following the request to have an expert in maori culture in attendance so that discussions could be held at a cultural level.

Further discussions around the importance of the area were held and over the programme.

A relationship will be formed with Te Kawerau lwi Tribal Authority and all information will be passed to them, i.e. MMIA, MMO report.

Ngati Manuhiri Settlement Trust

A phone call was held with the chief executive and were happy to receive information electronically due, which was provided.

Taharoa C Block

A phone call was held with the chief executive and were happy to receive information electronically due, which was provided.

Auckland University

was contacted and provided a copy of the TGS information sheet, but no further contact was received.

Dan Govier

From:

N#Iodyhoo

Sent:

Vxqgd #47#Vhswhp ehu#5347# =37#s1p 1

To:

Gdq#Trylhu

Subject:

UH#Sursrvhg#Vhlvp lf#Vxuyh

my sincere apologies Dan - the guy that was suppose to meet with you

obviously didn't turn up.

if you don't mind - just keep me updated - that will suffice.

Again my apologies

Regards

From: dan@eosltd.co.nz

Date: Tue, 9 Sep 2014 21:27:29 +1200 Subject: RE: Proposed Seismic Survey

Tēnā koutou,

We turned up to 11 Queen Street in Waiuku yesterday, Monday 8th of September at 1-30pm but unfortunately no one showed up to meet with us as was arranged below.

After waiting half an hour inside the venue, I left my card with the person working there and we left.

So it was unfortunate that we could not meet and provide you with more details on what is proposed.

My client from TGS has now headed back to Singapore and we have left Auckland.

I will keep you updated on what is happening with the survey proposal.

Nga mihi,

Dan

Sent: Monday, 1 September 2014 10:31 a.m.

To: Dan Govier

Subject: Re: Proposed Seismic Survey

11 gueen st Waiuku c u there.

Sent from my iPhone

On 1/09/2014, at 10:12 am, Dan Govier < dan@eosltd.co.nz > wrote:

Kia ora

Just following up on my email below and that we are confirmed to meet at 1-30pm on September \mathbf{g}^{th}

Do you have any idea of a venue we could meet you?

Nga mihi Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Tuesday, 26 August 2014 3:51 p.m.

To: Cc: '

Subject: RE: , roposed seismic survey

Kia ora

Thank you for the reply.

If we could make the meeting 1.30pm on 8th September that would be appreciated.

I am unsure of a venue, if you have offices we can meet in we will come there or open to suggestions.

I will likely be flying into Auckland around midday on the 8th so will be out at the airport area so can arrange to meet you wherever.

Our next meeting is at 4pm so we will have plenty of time to go through things.

And that is great if could join us also.

Nga mihi, Dan

Sent: Tuesday, 26 August 2014 8:42 a.m.

To: Dan Govier

Subject: RE: Proposed Seismic Survey

Dan

How about 10th Sept at 2pm?

failing that then perhaps - 8th Sept at 1.30pm.

Let me know where you want to meet.

We really want to get a 'handle' of what is being proposed.

Regards

cc: Im ok with being there

From: dan@eosltd.co.nz

Date: Fri, 22 Aug 2014 15:13:32 +1200 Subject: RE: Proposed Seismic Survey

Kia ora .

We will be back in the Auckland Region at the start of September and would like to meet with you and discuss the proposed seismic survey and gain a further understanding of you cultural perspectives and traditional relationship with the coast.

We will be in the Auckland/Waikato region on 5th-6th of September and then again on the 8th-10th of September.

What day would be best for you? It is likely that I will fly into Auckland at midday on the 8th so we could meet early afternoon if you want to meet on a Monday?

Also would attend this meeting to also represent the Ngati Paoa Trust Board or would that need to be a separate meeting?

Nga mihi, Dan

<image002.jpg>

Sent: Friday, 25 July 2014 3:13 p.m.

To: Dan Govier

Subject: RE: Proposed Seismic Survey

Kia ora Dan

you need understand our cultural perspectives and traditional relationship to the coast before you proceed with your project.

I will need to arrange my medical schedule around if I'm to meet you on Monday - which Monday and where do we meet exactly. I would prefer to meet at 3.00pm

Na

From: dan@eosltd.co.nz

Date: Fri, 25 Jul 2014 14:06:10 +1200 Subject: RE: Proposed Seismic Survey

Tēnā koe

Thanks for the email.

Yes I intended to make contact with Ngati Te Ata, you are on my list. Unfortunately we cannot meet with you on the 29th or Friday 1st next week due to prior arrangements sorry.

A bit of back ground, TGS has applied for a prospecting permit to undertake a seismic survey, this is still going through the approval process with government. I understand that Ngati Te Ata have been sent the details of the application by NZ Petroleum & Minerals.

TGS are purely a service provider. They acquire seismic survey data only, they do not drill wells so will not be undertaking any exploration drilling activities.

We have made a number of mitigation measures and changes to the survey design to ensure there is the least amount of disturbance to the marine environment and marine mammals.

What we would like to do is meet with you to introduce TGS, introduce the survey area and also discuss the regulatory regime and mitigation measures that will be in place for the proposed survey.

We will be in Auckland on Monday afternoon but fly out again at 4-30 pm, at this stage we are free between 11-30 until about 4pm. So hopefully we can meet with yourself so please let me know if this timing suits.

TGS is based overseas; however, we will be back in Auckland again shortly so it would be good to try and meet with you next time we are in Auckland. It is likely to be at the end of August/early September.

If I can provide any further information please let me know.

I have attached an information sheet on the proposed seismic survey.

I sent an email to yesterday also as well as leaving a phone message to try and meet with I see her name was included below, so hopefully she had received the messages and was aware of the proposal and request for a meeting too.

Nga mihi, Dan

<image003.jpg>

Sent: Friday, 25 July 2014 1:49 p.m.

To: dan@eosltd.co.nz

Subject: FW: Proposed Seismic Survey

Dan

You need to meet with Ngati Te Ata - we hold the mana from Manukau Heads to Waikato North head (coastline)

I am available Tuesday 29th late arvo or Friday morning - confirm then contact me for further instruction.

Tuesdays and Fridays are my days.

na

Date: Thu, 24 Jul 2014 18:39:42 -0700

Subject: Re: FW: Proposed Seismic Survey

I'll forward to mum and

Sent from Yahoo Mail for iPad

>;

Subject: Re: FW: Proposed Seismic Survey

Sent: Fri, Jul 25, 2014 1:23:27 AM

Kia ora korua

I know everyone is really busy with everything going on, but just wondering if this guy has made contact with either of you to meet to discuss this. From my limited knowledge I think they are doing this to get our support for this TGS company to do some drilling. I think they are doing a one by one meeting with different Iwi to of course get support.

Does your mother know about this

I would support opposing this really strongly.

Let me know what you's think.

Nga Mihi mahana

On Thu, Jul 24, 2014 at 3:54 PM, Dan Govier <dan@eosltd.co.nz> wrote:

Kia ora

Thanks for calling me back.

As discussed I am working with a company called TGS proposing to undertake a seismic survey towards the end of this year. There are further details in my email below and likewise in the attached Information Sheet.

We will be in Auckland on Monday 11th of August and at this stage have the afternoon available if you were able to meet with us so that we can introduce TGS and the proposed survey, the mitigation measures in place and the regulatory process which has to be undertaken.

If you require any more information please let me know

Nga mihi Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sont: Thursday 19 June 2014 10:13 p.m.

Subject: Proposed Seismic Survey

Tēnā koe

I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014.

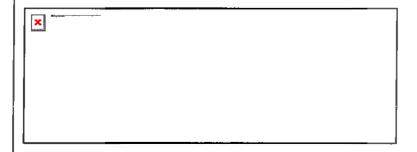
TGS have applied for a prospecting permit from NZ Petroleum & Minerals which is currently being processed; however, we would like to take the opportunity to come and meet with you and introduce TGS and the proposed seismic survey programme to you.. I have attached the area which TGS has applied for from the government.

Would representatives from the Ngati Paoa Trust Board be available to meet with us on Thursday 3rd July, dependent on where you are based? I am just trying to organise the order of the meetings but just wanted to make sure this was possible first before we confirmed a time.

If you require any further information in regards to this email or the proposed visit please let me know.

Thanks, I will look forward to hearing from you,

Nga mihi, Dan



Dan Govier

From:

щ Iulgd | #45#Vhswhp ehu#5347#9€;#s1p1 Sent:

To: €dq#Irylhu*

Subject: UH#Sursrvhg#hlvp lf#xuyh|

Ka pai Dan, thank you for keeping Ngaruahine in the loop.



Chief Negotiator / Office Manager

Nga mapu o ingaruanine iwi incorporated

From: Dan Govier [mailto:dan@eosltd.co.nz] Sent: Friday, 12 September 2014 5:11 p.m.

Subject: RE: Proposed seismic survey

Tēnā koe

We were in contact earlier this year regarding a proposed seismic survey off the northwest coast of NZ by TGS.

I have attached an information sheet which provides a few further details of the survey.

Just as an update, the permit has still not been approved and we are currently preparing the Marine Mammal Impact Assessment.

Nga mihi,

Dan

Sent: Monday, 16 June 2014 11:15 a.m.

To: 'Dan Govier'

Subject: RE: Proposed seismic survey

Hi Dan

Thank you for the email. Ngaruahine does not need to meet with you, but if you wish to keep us in the loop information wise that would be appreciated.



Chief Negotiator / Office Manager / Iwi Registrar

Ngā Hapū ō Ngāruahine Iwi Incorporated

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 16 June 2014 10:59 a.m.

To:

Subject: RE: Proposed seismic survey

Tēnā koe

We are going to be visiting Taranaki on June 30th – July 1st to undertake some meetings regarding the proposed seismic survey that TGS have applied for a prospecting permit from NZPaM.

Given your comments below regarding the location of the survey, would you like to meet with us to discuss the proposed survey? I am just trying to set up meetings at the moment

If you do not require to see us, I would still like to keep you updated with how everything progresses and provide you with further details of the survey etc.

Nga mihi

Dan



Sent: Tuesday, 27 May 2014 8:28 a.m.

To: dan@eosltd.co.nz

Subject: FW: Proposed seismic survey

Tena koe Dan

Thanks for the email, however I am unsure if your proposal relates to the tribal area of Ngaruahine as we are further around from New Plymouth. The only way I will know for sure is if you send an area map showing where the proposal is likely to go. In the meantime I have cc in two other ladies from their respective tribal areas who could potentially be the affected parties.

Look forward to receiving the information.

A

Chief Negotiator / Office Manager / Iwi Registrar

Ngā Hapū ō Ngāruahine lwi Incorporated

Sent: Tuesday, 27 May 2014 8:23 a.m.

Subject: FW: Proposed seismic survey

Tena korua

Not sure where this is exactly but you may want to make inquiries. In the meantime I will do the same.

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 26 May 2014 10:44 p.m.

Subject: Proposed seismic survey

Kia ora

I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014. The southern part of the survey area is located 130 km northwest of New Plymouth.

TGS have applied for a prospecting permit from NZ Petroleum & Minerals which is currently being processed; however, if you are interested we would like to take the opportunity to come and meet with you and introduce TGS and the proposed seismic survey programme to you.

Would you be available to meet with us on the 3rd or 4th of June? I am just trying to organise the order of the meetings but just wanted to make sure you are available first before we confirmed a time. If you are unavailable we can provide electronic information and maybe catch you on another visit.

If you require any further information in regards to this email or the proposed visit please let me know.

Thanks, I will look forward to hearing from you,

Nga mihi, Dan

Dan Govier

Environmental Consultant

www.eosita.co.nz



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Dan Govier

From:

Mip#Vp kodh

Sent:

Iulgd | #18#0xjxw#5347#; -65#11p 1

To:

Gdq#Jrylhu

Subject:

UH#IJkhuhv#Dvvhvvp hqw

Thanks Dan

Regards

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursday, 14 August 2014 5:15 p.m.

Subject: Fisheries Assessment

Kia ora.

Thank you for your time this morning, it was nice to meet you

As we discussed, please find attached the fisheries assessment we had undertaken from the proposed survey area.

The 300 m contour line is marked on the maps, the proposed survey will mostly occur beyond this depth.

Thanks

Dan

Dan Govier

Environmental Consultant

www.eosita.co.nz

ENVIRONMENTAL
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Dan Govier

From: Sent: To:	ethqgrq#jthhq Wkxugd #6#kd #5347#3=8 : #11 Gdq#Jry]hu	þ 1
Subject:	Uh#Riivkruh#n{sorudwirq#qwurq	gxfwru ‡p hhwigj
Thanks Dan. I'll follow up with It was a pleasure meeting with y	-	zairo.
On Thu, Jul 3, 2014 at 8:38 AM	, Dan Govier < <u>dan@eosltd.</u>	.co.nz> wrote:
Kia ora		
Thanks very much for your time t about Ngati Hikairo.	o meet with us yesterday, it wa	vas really good to meet with you and hear more
I have answered your questions b	elow in red as I figure that is t	the easiest approach.
I have also attached a couple of bethat may be of interest to you.	rochures on seismic surveys ar	nd underwater sound in the marine environment
We will have an electronic version	n of the information sheet to y	ou shortly.
Nga mihi,		
Dan		
Sent: Wednesday, 2 July 2014 11: To: Dan Govier	∠5 a.M.	
Cc: Subject: Offshore exploration intr	oductory meeting	
Hi Dan, thanks for your call and	I see you this afternoon.	may not be able to make it so
please count on just me.		

Questions we have which we'll appreciate you explaining to us are:

- 1. Permit area. You have provided this so thank you.
- 2. Who the company is: TGS. Make up and the company/consortia.
 - a. Who will be carrying out the exploration activities?
 - b. Who else is competing for the permit

I have attached a one page information sheet on TGS. If you would like to find out more about TGS, the website has a lot of detailed information and is listed on the attached sheet.

TGS will be conducting the seismic survey, but that is the extent of TGS's activities, they will not be undertaking any further stages of exploration other than seismic surveys.

No one else is competing for the permit, TGS have applied to NZ Petroleum and Minerals for the Petroleum Prospecting Permit, and the application area was attached in your email.

3. Timeline. Timeline to obtain permit and undertake activities

A decision is to be made by NZ Petroleum and Minerals whether the prospecting permit is approved approximately July 27th. TGS are proposing to commence the seismic survey at the start of December 2014 and it is likely to be complete in March/April 2015.

4. Who we are: Our people Ngati Hikairo of Kawhia are the hau kainga (local people) from the Tainui Waka that settled over 800 years ago. Our Marae is Waipapa and we connect to the whenua, the harbour of Kawhia and Karewa which are the islands off Kawhia.

Thank you for your summary of the Kawhia region and the importance of it to the people of Ngati Hikairo yesterday.

- 5. What is important to our people: the area that the permit encroaches on our rohe (region) and in particular protecting:
 - a. Karewa islands
 - b. Kawhia beach
 - c. Kawhia harbour
 - d. Ecology and environment of these areas

The mitigation measures that TGS will implement will make best endeavours to minimise any potential effects on the marine environment or the marine life which is present. As we discussed, TGS has had Sound Transmission Loss Modelling undertaken which defines the emitted sound levels from the acoustic source and is used to validate the mitigation zones that are stated in the Code of Conduct and have to be adhered to during the survey.

As a result of this modelling, the survey design was further refined and the inshore boundary of the survey area has been moved further offshore and away from the marine mammals sanctuary. The closest survey line (i.e. where the vessel will have an operational acoustic source) to the Kawhia harbour entrance is 102 km. The inshore boundary of the seismic survey will be along the 300 m contour line.

- 6. Process: To understand the above (in point 5) we invite TGS to outline the effects and mitigation of such effects as would arise from the activities of the proposed exploration. To achieve this suggestions are:
 - a. Summarise key steps of the exploration (you have provided information of the seismic surveys thank you)
 - b. Preparation of a report of effects and mitigation

Under the EEZ Act, seismic surveys are classified as a permitted activity as long as the operator adheres to the DOC 2013 Code of Conduct for minimising acoustic disturbance to marine mammals.

The Code of Conduct requires a Marine Mammal Impact Assessment (MMIA) to be prepared, sound transmission loss modelling to be completed that is specific to the actual acoustic source to be used, and implement mitigation measures, including adherence to the required mitigation zones during the survey.

There are three mitigation zones defined in the Code of Conduct and what TGS will operate in accordance to. There will be 4 marine mammal observers on the seismic vessel during the survey which monitor these mitigation zones, two as visual observers and two that will operate the Passive Acoustic Monitoring (PAM) device. The PAM system is a towed hydrophone behind the vessel which listens to the echolocations of marine mammals and can detect dolphins and whales.

These observers are independent of TGS and have to be suitably qualified to undertake this role. These observers monitor for marine mammals in reference to the mitigation zones and have the full authority to shut the acoustic source down if a mammal enters the relevant mitigation zone. The mitigation zones require that if a marine mammal and calve come within 1.5 km of the acoustic source, the acoustic source has to be shut down. If there are no calves present, the mitigation zone is 1 km, and for all other marine mammals, i.e. dolphins it is 200 m. The acoustic source cannot be started again until the marine mammals have been observed to leave the mitigation zone.

Once the vessel can resume operations following the mammals leaving the mitigation zone, it has to undertake a procedure called a soft start. This involves slowly increasing the volume of the acoustic source over a 20 minute period. This acts as a mitigation measure, where any marine mammals that may be in the area and if they are uncomfortable with the slow increase in noise, will move away slightly to avoid the noise. Studies have shown that once a seismic survey stops, marine mammals will come back into the area, due to the fact that once the sound has gone there is no further effect.

As part of the MMIA process, the sensitivities of the surrounding environment, existing users and those with cultural importance are assessed for what potential effect the seismic survey could have and what mitigation measures are to be implemented. The Director-General of DOC has to approve this MMIA prior to the survey commencing. There is a stipulated timeline for the MMIA submission where it must be lodged no later than one month prior to the survey starting. If any changes are required, they will be made before it is approved and you will only see the finished version, as once it is approved DOC are then satisfied that the potential effects to the marine environment have been minimised to as low as reasonably practicable.

c. Presentation of this at a hui at Waipapa Marae and follow up sessions that may be required from the hui.

Thank you for this invite, we will advise when TGS is next in the country and see if we can attend and present at your Marae if timing and schedules allow.

- d. Payment to Ngati Hikairo for costs incurred in reviewing the material that includes all reasonable costs of:
 - i. Representatives from Ngati Hikairo
 - ii. Marae costs for the hui and catering
- e. Ongoing liaison between representatives of Ngati Hikairo and TGS and reimbursement of costs associated with the liaison.
- 7. Our fears: Examples of BP's Event Horizon in the Gulf of Mexico and closer to home the Rena are not positive experiences for our iwi. We have been the kaitiake (guardian) for our rohe for over 800 years and we see this continuing for another 800 years.

TGS's proposed activity is purely only related to the acquisition of a seismic survey. TGS do not drill wells as part of their business. For the seismic survey operations an acoustic source is towed behind the boat ~450 m behind to release the acoustic source, which comprises of compressed air, fed by compressors on the seismic vessel and directioned down towards the seabed. A 10 km streamer is towed behind the vessel, and has hydrophones positioned all the way along the streamer to record the returned signals from the geology below the seabed. This streamer is solid filled. As a result there is no risk of oil spilling during a seismic survey. There is a tail buoy on the end of the streamer with a flashing light and radar reflector. The streamer is about 4.5 inch diameter and is below the water surface, slanting at 8 m below the surface behind the vessel, down to 30 m at the end of the streamer

The only oil involved is the fuel onboard the survey vessel and is essentially like any other vessel at sea; however, the survey vessel has the latest and greatest navigation equipment onboard and there is also a support vessel in close proximity at all times that can intercept ay vessel that is not aware of the survey being conducted. The presence of the support vessel, the navigation equipment, adherence to the Collision Regulations and Maritime rules will ensure that there will be no oil spill.

- 8. Our desires: to be informed, to build capacity in the area of exploration and to potentially participate in the project. Examples of participation include employment and financial benefits in the development.
- 9. Overall position: Rather than take an 'oppose exploration' position our interest is to constructively engage with exploration companies, build a relationship based on open dialogue so that in exercising our kaitiake we may understand the risks and mitigation so that we can make an informed decision about the proposed investigations which may lead to exploration and ultimately development of oil/gas production facility that potentially effects our rohe.

This is very good to hear, and we are certainly willing to help provide you with information and answer any questions that you may have regarding this industry, as it is relatively unknown to a number of people.

TGS's proposed 2D survey will be utilising a specialised seismic vessel with advanced seismic equipment on board to gather an accurate set of data. With the survey covering such a large expanse, it means that this survey should suffice for a number of years and prevent a lot of smaller surveys being conducted. If after the results are interpreted and operators believe there is something of interest there, TGS may look for future seismic activities to create more definition of the bottom structure.

With state of the art surveys being conducted now like what TGS are proposing, it means that if a well is to be drilled in a number of years' time it will be drilled on the best information. What has happened previously is that there have been a lot of dry wells drilled, but it appears the information they used to select a drilling location was not that accurate. So having accurate data available may minimise the number of wells that will be drilled in the future.
Attached is a heritage environment plan that provides further information for you to digest.
Thank you for this plan, very interesting, a lot of work has gone into generating that report.
Hook forward to seeing you this afternoon at circa 1:30pm.
Ngati Hikairo

Dan Govier

From:

Dajhdah#Juhhavlo

Sent:

P rggd #53 #kgh #5347 #44 #85 #s 10 1

To:

Gda#Jrvlhu

Subject:

Uh#Sursrvhq#hlvp lf#xuvh

Kia ora Dan.

I have commitments from Tuesday to Thursday this week but am free on Friday. Perhaps you can forward all necessary information so I can pass it on to our hapu who meet monthly on the second Sunday of the month to discuss matters such as this.

Heoi ano

Environmental Spokesperson Tainui Hapu Whaingaroa/Raglan.

On Sunday, 29 June 2014 6:14 AM, Dan Govier <dan@eosltd.co.nz> wrote:

Kia ora

Thanks for your email.

Yes I am making touch with the Tainui hapu along the west coast, the biggest problem is that I am not getting replies from people or the contact details I have are incorrect or old.

If you can provide me with up to date contact details for these hapu it would be appreciated. I have been in touch a few times now with Tim Manukau from Tainui regarding this survey.

The proposed seismic survey is well offshore from the Marine Mammal Sanctuary. The actual survey area was moved further offshore as a result of this sanctuary being in place. We have just had some Sound Transmission Loss Modelling undertaken to attain sound exposure levels that will emanate from the survey and to ensure compliance with the mitigation zones within the DOC Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals.

As a result of this report, the shallowest depth that the seismic survey will operate in is 300 m, this is well beyond the core range of Maui's Dolphin.

I have included a few distances below of the survey that may be of interest to you.

From the harbour entrance at Whaingaroa, the closest survey line will be 83 km offshore; and From the entrance to Kawhia harbour the closest survey line is 102 km.

So as I said, we can be in the Raglan/Waikato region Tuesday afternoon and all of Wednesday and at this stage are flexible with time, so if you are able to meet with us to hear more about the survey and raise the concerns you have that would be greatly appreciated.

Nga mihi

Dan



Sent: Sunday, 29 June 2014 12:22 a.m.

To: Dan Govier

Subject: Re: Proposed seismic survey

Kia ora Dan,

The block offer area includes the Rohe Moana of several Tainui hapu along the west coast and therefore contact with these hapu needs to occur prior to any surveys being undertaken. It is also within the area frequented by the endangered Maui Dolphin, orca and other marine mammals. It is unlikely that Tainui will support these activities in our traditional waters. heoi ano

Environmental spokesperson Tainui

On Friday, 27 June 2014 12:11 PM, Dan Govier < dan@eosltd.co.nz> wrote:

I have been trying to get in touch with you regarding a proposed seismic survey. See my emails below for further details.

We will be in the Waikato region on Wednesday and it would be good if we could catch up with you

Nga mihi, Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]

Sent: Monday, 16 June 2014 10:47 a.m.

To:

Subject: FW: Proposed seismic survey

Tēnā ko€

As per my earlier emails, we will be travelling through the Waikato region on July 1-3 and was hoping you would be available to meet with us so we can introduce TGS and the proposed survey.

If you could please let me know if you are available that would be greatly appreciated.

Nga mihi,

Dan



LIMITED

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Wednesday, 28 May 2014 3:42 p.m.

Subject: Proposed seismic survey

Kia ora

I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014.

TGS have applied for a prospecting permit from NZ Petroleum & Minerals which is currently being processed; however, we would like to take the opportunity to come and meet with you and introduce TGS and the proposed seismic survey programme to you. I have attached a map showing the prospecting permit application area.

Would you be available to meet with us on the 5th of June or potentially first thing in the morning of the 6th of June? I am just trying to organise the order of the meetings but just wanted to make sure you are available first before we confirmed a time.

If you require any further information in regards to this email or the proposed visit please let me know.

Thanks, I will look forward to hearing from you,

Nga mihi, Dan

Dan Govier
Environmental Consultant

Www.eosltd.co.nz

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Dan Govier

From: Gdq#Jryhu

Sent: Z hgqhvgd | #58#xqh#5347株-67#2 1

Subject: UH-#hkp ff#/xuyh |
Attachments: vhkp ffb/xuyh | vb35lep s

Tēnā koe

I have tried to provide you with some further details regarding the questions in your email below.

TGS are a leading provider of multi-client seismic data and related geoscientific products to the oil and gas industry. Their main offices are in Houston and Oslo with regional offices in London, Perth, Calgary, Singapore and Rio de Janeiro. The company has approximately 850 employees. I will send you some further information on TGS once I have it available.

Yes TGS have operated in NZ previously. In 2001 they undertook a deep water seismic survey in the Taranaki Basin. However this was operated under a scientific permit as it was prior to the Code of Conduct and EEZ Act were introduced.

TGS are purely a service provider of seismic data. So they will not be doing any exploration drilling as part of this process. They undertake the seismic survey using the latest available technology and then make this information available if an operator wants to have a look at the subsea geology in the region.

I have attached two schematics showing the basic principles of a seismic survey. The difference between a 2D survey and a 3D survey is essentially the number of streamers deployed behind the vessel. A 2D survey only has one streamer, while a 3D survey can have up to 10-12 streamers. The acoustic source which makes the noise during a seismic survey is simply a bubble of compressed air which is directed down towards the seabed and the noise is when it implodes on itself.

From Marakopa the closest survey line is 143 km; From Whaingaroa harbour entrance the closest line is 83 km; and From then entrance to Kawhia harbour the closest line is 102 km.

The survey is proposed for December 2014 to make use of the settled weather.

The survey is to gain an understanding the geology and structures of the underlying seafloor and to look for areas of interest which may potentially contain hydrocarbons

The survey has to adhere to the DOC Code of Conduct for minimising acoustic disturbance to marine mammals. There are a number of mitigation measures and requirements within the Code of Conduct and a Marine Mammal Impact Assessment (MMIA) has to be prepared and approved by the Director-General of DOC before the survey can commence. The MMIA process looks at the surrounding marine environment, what the sensitivities are, what marine mammals are likely to be present in the area, what users are likely to be in the area etc and also the mitigation measures that will be implemented during the survey to mitigate any adverse effects.

Sound transmission loss modelling gets undertaken which is used to validate the acoustic source against the mitigation zones that will be implemented during the survey. The mitigation zones in place mean that if a marine mammal comes within a certain distance of the acoustic source, the vessel has to shut down the acoustic source and cannot commence until the marine mammals have been observed to leave the relevant mitigation zone for at least 30 minutes.

There are two visual marine mammal observers on the vessel and two observers who undertake Passive Acoustic Monitoring, which is a towed hydrophone which listens to the echolocations of the marine mammals and is another

method of ensuring there are no marine mammals close to an active acoustic source. These observers are independent from TGS and have the authority to stop the survey if a marine mammal comes within the relevant mitigation zone.

Joint monitoring programmes, this is a hard one. The biggest issue with having an iwi monitor onboard the vessel is simply the lack of beds on the vessel, as there is a full complement of crew onboard the survey vessel and four additional marine mammal observers so room is tight. There are also health and safety issues with having someone who is not suitably trained being onboard the vessel, as they would have to be helicoptered out to sea and have the correct training to be able to that also. The best way would be if a representative on the trust board could train to become an observer. There are companies which are starting to run training courses for marine mammal observers who have no prior experience, and then once they are qualified, they can work on a vessel with the marine mammal observers and then report back to the trust board. This would be beneficial for future surveys up off that coastline if you could have some of your people involved and being able to report back.

This is just a quick summary sorry, the best option is if we can get in front of your board and then we can give you a more detailed account of what is involved, what the processes are etc.

If you can please let me know when we would be able to meet with you, and whether there is the opportunity to meet with you next Tuesday/Wednesday when we will be in the region?

Nga mihi, Dan

Sent: Wednesday, 25 June 2014 9:15 a.m.

Subject: RE: Seismic Survey

Tēnā koe Dan

Thanks for the map. It is always helpful for whanau to have information prior to presentations so we can be prepared for question and answer time.

Please forward:

- Company information sheet
- Identify if the company has any other NZ region portfolio survey
- image of 2D Seismic Survey to show what the company will be doing (visual is helpful rather than words)
- > outline how many kilometres off the west coast from Marokopa, Whaingaroa, Kawhia you will do extensive 2D seismic survey
- when will the survey be done
- what are you looking for in the survey
- outline methodology to do marine mammal assessment prior and post seismic survey
- > outline examples of joint monitoring programs with tangata whenua communities

We look forward to receiving your information.

Ngā manaakitanga

Kaiwhakahaere Whanake Taiao Maniapoto Maori Trust Board Maniapoto Maori Trust Board

"Ā muri kia mau ki tēnā, kia mau ki te kawau mārō, whanake ake, whanake ake - In Unity there is strength"

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From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursday, 19 June 2014 9:07 p.m.

7

Subject: RE: Seismic Survey

Kia ora

Please see if the attached document works this time.

Thanks for the clarification of your board and the process they need to work through. We are preparing the MMIA at the moment and likewise the mitigation measures and that's why we were hoping to get in front of as many groups as we can as early as possible.

If you can please let me know when the board can accommodate us we will try to attend and ensure that TGS are in the country. It is just difficult with the international travel. We would prefer to meet with the board rather than go to each of the regional management committees as we are engaging with so many groups up the north island, where possible to get all the board members in one room would be greatly appreciated.

Please let me know if you have any further questions or if you can offer some tentative dates when the board can meet with us that would be greatly appreciated.

Nga mihi, Dan

Sent: Thursday, 19 June 2014 10:16 a.m.

To: 'Dan Govier'

Subject: RE: Seismic Survey

Kia ora Dan,

Thanks for your response. I tried to open your attachment but it's coming up blank.

I would like to accommodate your request to meet with the Board but there is a process that needs to be undertaken and briefings that need to take place before they will meet with external companies. The Board usually require two months' notice, is this a possibility? Alternatively, you could contact the Regional Management Committees (eg. Nga Tai o Kawhia, Hauauru ki Uta, Mokau ki Runga) to arrange to meet with them? In saying that, Nga Tai o Kawhia will not be meeting until end of July.

Aku mihi nui,

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Wednesday, 18 June 2014 3:11 p.m.

Subject: RE: Seismic Survey

Kia ora

That is a shame that did not receive my email, I was going to get in touch later today to follow up. I have attached the email I sent on Monday.

The only other additional information I can really provide at this stage is that TGS have applied for the prospecting permit. If the permit area is awarded then TGS propose to undertake an extensive 2D seismic survey within the permit. A 2D seismic survey is where a seismic vessel releases a sound source which is a bubble of compressed air and the sound reflections are received on a 10 km long streamer which has hydrophones placed along it to receive the signals. Much like a large version of a fish finder.

We are going to prepare a Marine Mammal Impact Assessment and as part of that mitigation measures will be in place to ensure there is no harm to marine life.

It will be best is if we can get in front of your board and they can ask us any questions after we give a presentation on the process, regulations and survey etc.

At this stage hopefully the board would be able to meet with us either late Tuesday 1 July or the morning of Wednesday 2 July?

I can send the same email and permit area to that email if you like?

When do you next meet as we will have to ensure the representative from TGS is in the country.

Nga mihi

Dan

Sent: wednesday, 18 June 2014 2:54 p.m.

To: 'Dan Govier'

Subject: RE: Seismic Survey

Kia ora Dan,

Thanks for your email. I have spoken with and unfortunately she did not receive your email. Could you please re-send it?

I have also had a look through our Inwards Correspondence and we have not received the application. If you could please send us as much information as possible then we can start putting together information for our Trustees to have a look at. If they are happy with that, then we can proceed to organise a date to meet. Just to confirm, yes I am on the Nga Tai o Kawhia RMC. If you would like to meet with us, you will need to send the information and I will ask the Chair if you can be added to our agenda in July 2014 as we only meet every 2 months. I look forward to hearing from you shortly.

Aku mihi nui,

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 16 June 2014 4:25 p.m.

Subject: KE: Seismic Survey

Kia ora

Thanks for the email, I got one of your emails bounced back to me that I was provided with for you at the Maniapoto trust board, so I tried to get hold of you on the phone also. I ended up speaking with and have sent her an email, so you may want to discuss with her.

I think I met you a couple of years ago, when I visited the MMTB with my client Schlumberger to discuss their seismic survey.

Anyway the process is, TGS have applied for a prospecting permit from the government, which is currently going through the application process and the MMTB should have received this information already or if not, will do very shortly.

TGS and myself are starting engagements with groups along the survey area to introduce the company and the proposed survey etc. Seismic surveys are a permitted activity under the EEZ Act as long as they are operated in accordance to the Code of Conduct. So a Marine Mammal Impact Assessment has to be prepared and this has mitigation measures in place. So the consultation and engagements we are undertaking will be a part of the MMIA.

This MMIA has to be approved by the Director General of DOC prior to the survey commencing, and consultation with iwi and stakeholders is a part of this. It is different to a consent application/process and does not require written approvals for the activity to commence but we want to ensure we have contacted everyone and informed of the proposal.

If you have any further questions please let me know

But we are hoping to come and visit either late afternoon on July 1 or the morning of July 2nd to introduce TGS and survey area. hopefully this will work.

I see your name is also down as the contact person for the Nga Iai o Kawhia Regional Management Committee?

Nga mihi, Dan

Sent: Monday, 16 June 2014 3:50 p.m.

To: 'dan@eosltd.co.nz'
Subject: Seismic Survey

Kia ora Dan,

Thank you so much for your emails.

I really appreciate this opportunity to work with yourself and your company.

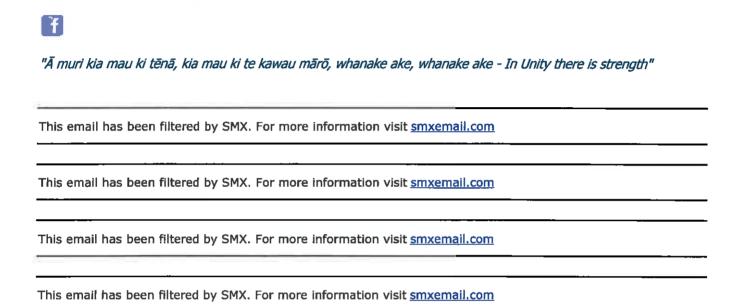
What would be helpful for me in informing the MMTB, is if you could please send through information on what you are proposing and ideally what you would like from MMTB in that regard.

The process from here is for me to make recommendations to our Environmental Subcommittees and they make recommendations to the MMTB. It can be a long process of possibly a month or longer and may not be conducive to the process that you are going through.

Please let me know how this may/may not work for you.

Hei konā mai i roto i ngā mihi,

Kaitātari Kaupapa Matua | Whanake Taiao Senior Policy Analyst | Environment Maniapoto Maori Trust Board



Dan Govier

From:

Gdq#Jrylhu

Sent:

Wxhvqd #57#kqh#5347# = 76#s to 1

To:

Mio #P daxndx

Subject:

UH#Sursrvhg#hlvp lf#xuyh|

Kia ora T

I have tried to get hold of 3

a number of times now but I have had no luck. I got a

reply from Heather but the email has now continued to bounce back to me.

Do you have phone numbers for them I could follow up with?

We are heading through the Waikato next week so want to at least touch base, and it would be great if they could meet with us if timing worked also.

Nga mihi,

Dan

Sent: Monday, 16 June 2014 12:40 p.m.

Cc: Dan Govier (dan@eosltd.co.nz)
Subject: FW: Proposed seismic survey

Kia ora

Can you forward Dan Govier the Ngati Hikairo - Kawhia contact as well.

Dan – Im all over the place at the moment, priority please meet with the local tangata whenua.

Nga mihi,

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 16 June 2014 10:43 a.m.

Subject: RE: Proposed seismic survey

Hì

We will be travelling through the Waikato region around July 1-3 to discuss the proposed seismic survey again, as per my earlier emails.

Are you available to meet with us during that period? I am still working out the schedule so I don't have the exact date as to when we will be in town.

I will contact those listed below again that you provided me the contact details earlier so hopefully they will this time.

id not respond

Nga mihi, Dan From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Wednesday, 28 May 2014 3:26 p.m.

To: 'Tim Manukau'

Subject: RE: Proposed seismic survey

Hi

Thanks for those details I will get in touch with them. I have emailed her, so I will try that different email address listed below too.

already but have not heard back from

Are you available for us to meet with you next week on either Thursday afternoon or Friday morning? Or would you prefer us to deal with the people listed below?

Nga mihi Dan

Sent: Wednesday, 28 May 2014 1:35 p.m.

To: Dan Govier

Subject: RE: Proposed seismic survey

Hi Dan,

These are some of the local tangata whenua contacts for the below harbours. Please contact them directly.

Raglan (Tainui-a-whiro)

Aotea Harbour (Mahanga-Motakotako)

Kawhia Harbour (Ngati Mahuta)

Please ensure what is being proposed is consistent with our Waikato-Tainui Environmental Plan. http://www.wrrt.co.nz/environmental-management-plan/#sthash.UJNNLXjb.dpbs



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From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 26 May 2014 10:56 p.m.

Subject: Proposed seismic survey

Kia ora

I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014.

TGS have applied for a prospecting permit from NZ Petroleum & Minerals which is currently being processed; however, we would like to take the opportunity to come and meet with you and introduce TGS and the proposed seismic survey programme to you.

Would you be available to meet with us on the 5th of June or potentially first thing in the morning of the 6th of June? I am just trying to organise the order of the meetings but just wanted to make sure you are available first before we confirmed a time.

If you require any further information in regards to this email or the proposed visit please let me know.

Thanks, I will look forward to hearing from you,

Nga mihi, Dan

Dan Govier

From:

Gda#Jrylhu

Sent:

Wkxuvgd #4<#kgh#5347#<6:#3p 1

To:

Khdwkhu#Wkrp vrq

Subject:

IZ #Sursrvhg#Vhlvp lf#Vxuyh

Kia ora

My client from TGS is going to be back in the country at the end of this month, but unfortunately the visit is not be able to extend onto Sunday 6th of July to meet with your Marae.

We will be in the Waikato region on July 1-3 so if you do have any time available we could always call in to meet with you initially as I am not sure when the timing and travel will allow a Sunday visit to your monthly hui at this stage. However, we will still continue to try and make the timing work for a Sunday meeting at your Marae.

Nga mihi, Dan

Sent: Thursday, 29 May 2014 5:21 p.m.

To: Dan Govier

Subject: Re: Proposed Seismic Survey

Kia ora Dan, the Marae meets on the first Sunday of each month, (apart from the month of June) so just let me know when your client is able to attend.

Anō nei te mihi

On 28 May 2014 20:20, Dan Govier < dan@eosltd.co.nz > wrote:

Kia ora

Thank you for the reply and opportunity to attend your monthly Marae meeting.

Unfortunately my client has to fly home on Friday 6th June so we will not be able to make this meeting.

Is it possible you could email me your future meeting dates so we can try and attend one of those?

Nga mihi,

Dan

Sent: Wednesday, 28 May 2014 4:49 p.m.

To: Dan Govier

Subject: Re: Proposed Seismic Survey

Kia ora Dan, the most convenient time to meet would be at our monthly Marae meeting on the 8th June. The meeting commences at 10 am, would you indicate if you are able to attend and the number of people you might bring with you. We will allocate you a slot on the agenda.
anei hoki te mihi ki a koe
On 28 May 2014 15:43, Dan Govier < dan@eosltd.co.nz wrote:
Kia ora
I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014.
TGS have applied for a prospecting permit from NZ Petroleum & Minerals which is currently being processed; however, we would like to take the opportunity to come and meet with you and introduce TGS and the proposed seismic survey programme to you. I have attached a map showing the prospecting permit application area.
Would you be available to meet with us on the 5 th of June or potentially first thing in the morning of the 6 th of June? I am just trying to organise the order of the meetings but just wanted to make sure you are available first before we confirmed a time.
If you require any further information in regards to this email or the proposed visit please let me know.
Thanks, I will look forward to hearing from you,
Nga mihi,
Dan

Dan Govier

From:

Gdq#Jrylhu

Sent:

P rqqd #49#kqh#347指与6#1p 1

To:

Wip #P daxnax*#E d|ah#Kauilv*

Subject:

UH#Sursrvhg#whlvp lf#xxuyh

Thanks '

Yes Ngati Hikairo are on my list already and I will be making contact with them. If it is not this visit it will be the next.

Ok no problems will keep you updated once we have some electronic information to send out also.

Nga mihi

Dan

Sent: Monday, 16 June 2014 12:40 p.m.

Cc: Dan Govier (dan@eosltd.co.nz)
Subject: FW: Proposed seismic survey

Kia ora

Can you forward Dan Govier the Ngati Hikairo – Kawhia contact as well.

Dan - Im all over the place at the moment, priority please meet with the local tangata whenua.

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To: Dan Govier

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Aotea Harbour (Mahanga-Motakotako):

Kawhia Harbour (Ngati Mahuta)

Please ensure what is being proposed is consistent with our Waikato-Tainui Environmental Plan. http://www.wrrt.co.nz/environmental-management-plan/#sthash.UJNNLXjb.dpbs



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From: Dan Govier [mailto:dan@eosltd.co.nz] Sent: Monday, 26 May 2014 10:56 p.m.

Subject: Proposed seismic survey

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I am an environmental consultant working with a company called TGS who are proposing to undertake a 2D Seismic Survey in the waters off the west coast of the North Island at the end of 2014.

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If you require any further information in regards to this email or the proposed visit please let me know.

Thanks, I will look forward to hearing from you,

Nga mihi, Dan

APPENDIX 3

Technical Details of the PAM System



Report

Specifications for Vanishing Point Passive Acoustic Monitoring Systems

BPM-14-PAM specifications 05-09-14-v1.1 5/09/2014







Document Distribution List

Date: 5/09/2014

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1.1	05/09/2014	Review and update	LD	LD	LD
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			Aug.		

Document Reference Number: BPM-14-PAM specifications 05-09-14-v1.1

Prepared by:

Last updated: 5/09/2014

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1. Introduction

This document outlines the capabilities and specifications of Vanishing Point Passive Acoustic Monitoring (PAM) systems utilised by Blue Planet Marine (BPM) for seismic survey operations in New Zealand. These systems have been used extensive in New Zealand since 2006 and are compliant with the requirement for PAM systems as defined in the 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (the Code).

2. PAM System

BPM will supply a suitable PAM system for acoustic monitoring during the proposed survey. Importantly, the PAM system meets DOC specifications under the Code and will be tuned to the signature range of calls made by the marine mammal species likely to be encountered in the proposed survey area. Detailed specifications of the PAM equipment and software proposed by BPM for use during the survey is attached as Appendix 1.

BPM's PAM systems have proven to be highly robust and reliable. However, in order to allow for 100% redundancy during the survey, as required by the Code, we will provide:

- Two sets of on board PAM gear (i.e. computers, monitors, software, filters, amplifiers, sound cards and associated equipment); and
- Two PAM hydrophone cables.

Under the Code, the source may not operate in the absence of an active PAM system except for short periods when the PAM system is broken and is being repaired or replaced. The Code requires a complete backup PAM system to be carried. Given the importance of maintaining an active PAM system, BPM recommends that a minimum of three, rather than two hydrophones be included with the PAM system. PAM breakdowns are typically not the result of an intrinsic malfunction, but the result of environmental pressures on the hydrophone cable due to shark bite or entanglement. While BPM's personnel on board can undertake maintenance and minor repairs to equipment during a survey, major repairs (i.e. broken cables and loss of hydrophones etc.) must be repaired onshore.

The vessel is required to supply a suitable winch and associated equipment for mounting the towed PAM array for deployment and retrieval of the PAM hydrophone cable. If this is not possible, we can work with the vessel crew in order to develop alternative approaches.

3. Additional Details

The following information has been provided by the consultant to Vanishing Point

Sea Mammal Research Unit, St Andrews University) and BPM in response a DOC query about the specifications of the Vanishing Point PAM System.

The ability to detect animals, including the maximum range at which they can be detected, is critically dependent on the levels of background noise. To achieve a workable balance between signals and noise (i.e., the signal to noise ratio or SNR) the VP system utilises two independent hydrophone chains. Analogue filtering is utilised to customise SNR. The low frequency elements are AQ4s, the manufacturers state a near flat +/- 1.5dB sensitivity from 1Hz to 10 kHz. The high frequency chains have better omni-directional high frequency



sensitivity overlapping with the low frequency elements and are sensitive up to 250 kHz. The VP system is able to sample up to 500 kHz which is well in excess of the required 360 kHz. Therefore the VP system used by BPM has arrays incorporating appropriate hydrophone elements (1 Hz to in excess of 180 kHz range) and data acquisition card technology for sampling relevant frequencies (to greater than 360 kHz) used by New Zealand cetacean species. We confirm that this system has the capability to determine distance and bearing to 1.5 km and has full system redundancy.



Appendix 1:

Specifications of the PAM equipment

Hardware

Blue Planet Marine can provide various customised passive acoustic monitoring systems suitable for detecting and monitoring cetaceans during seismic survey. The full specifications of this system are not included in this document, however can be supplied on request.

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

The variety of cetacean species likely to be encountered during seismic survey mitigation produce vocalisations over an extremely broad frequency range, from the infrasonic 15-30 Hz calls of large baleen whales to the 130 kHz pulses of harbour porpoise and Hectors dolphin. To be able to capture all of these, while reducing unwanted noise the PAM system uses two different hydrophone/pre-amp pairs with widely overlapping frequency sensitivity: a low/medium frequency pair and a high frequency pair. These hydrophone pairs can be monitored, filtered and sampled independently.

Filtering and amplification hardware is custom-built by Magrec to meet the specification required for cetacean monitoring. Important features include: adjustable low frequency filters from 0 Hz to 3.2 kHz which can be applied to reduce low frequency noise allowing the available dynamic range to be conserved for capturing marine mammal vocalisations within the frequency bands used each species. The Magrec preamp also provides an output with a fixed 20 kHz low cut filter to optimise detection of the very high frequency vocalisations of porpoise, Hectors dolphins, beaked whales and Kogia. Additional, highly configurable digital band-pass and band-stop filtering is provided by on board signal processing within the specialised USB sound card.

Audio and low-ultrasonic frequency bands (up to 96 kHz) are digitised using a USB sound card. Ultra high frequency click detection (which is particularly useful for porpoise, Hector's dolphins, Kogia, etc.) is achieved by using a National Instruments Digital Acquisition card with a sampling rate of 1.2 mega samples s-1.

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

Software

The system is optimised for use with PAMGUARD. A software suite specifically designed for detecting, classifying and localising a wide variety of marine mammals during seismic surveys. Much of the funding for the development came from the oil exploration industry. Ecologic was part of the team



that initiated the PAMGUARD project and remains closely associated with its development. The hardware described here, has been developed in parallel with the PAMGUARD software.

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

PAMGUARD also includes routines for measuring and removing background noise, and for vetoing particularly intense sounds such as Airgun pules.

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

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

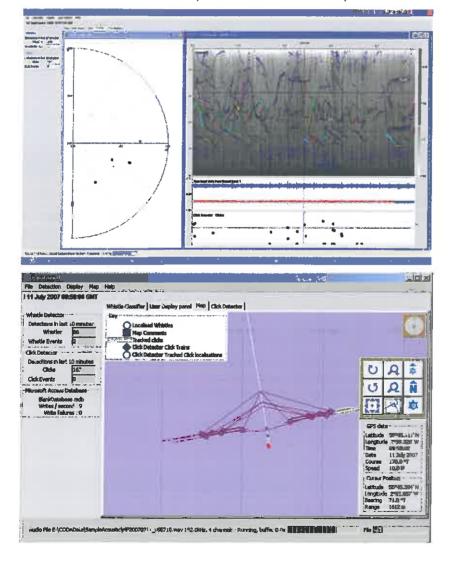




Figure 1 Screen shot from PAMGUARD Whistle and Click Detection and Mapping and Localisation Modules typical of a Seismic Mitigation configuration

Species Detection

The frequency range, call type and vocal behaviour of cetaceans varies enormously between species and this affects the degree to which PAM provides additional detection power, especially in the noisy environment of a seismic survey. This system has proven very effective in detecting small odontocetes and sperm whales, increasing detection reliability by an order of magnitude during trials (funded by Shell) conducted off the UK. PAM is particularly effective for the detection of sperm whales as they can be heard at significant ranges (several miles) and are consistently vocal for a large proportion of the time. Smaller odontocetes such as dolphins, killer whales, pilot whales and other "black fish" can be detected at useful ranges from both their whistle and click vocalisations but they often move so quickly that target motion may be difficult. The effective range for harbour porpoise (~400 m) is limited by the high rate of absorption of their ultra-high frequency clicks. This is usually within proscribed mitigation ranges so that any reliable detection should lead to action. Towed hydrophones of this type have been very effective in picking up vocalisations from beaked whales during surveys and the narrow bandwidth and characteristic upsweep in their clicks greatly assists with their classification. However, beaked whales clicks are highly directional and vocal output can be sparse and intermittent so overall detection probability may remain low.

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

Towed Hydrophone	
Acoustic Channels	2 x Medium Frequency Benthos AQ4. –201 dBV re 1μPa (+/- 1.5 dB 1-15kHz) with Magrec HP02 broad band preamps (LF cut filter @ 100Hz or 50Hz as required) Near-flat Sensitivity 1Hz- 10kHz with good sensitivity to higher frequencies
	2 x High Frequency Magrec HP03 units, comprising a spherical ceramic and HP02 preamp (Low cut filter set at 2kHz) Near flat sensitivity 2kHz- 150kHz. +/-6 dB 500Hz to 180kHz
Depth Sensor	Keller 4-20Ma 100m range Automatically read and displayed within PAMGUARD
Streamlined housing	5m, 3 cm diameter polyurethane tube. Filled with Isopar M.
Cable	340m multiple screened twisted pair, with strain relief and Kellum's grip towing eye, Length deployed may vary to suit application
Connectors	19 pin Ceep IP68 waterproof
Deck cable	~75m 19pin Ceep to breakout box
Topside Amplifier Filter Unit	
Unit	Magrec HP/27ST
Supply Voltage	10-35 V DC



Standard Seismic Mitig	gation Acoustic Monitoring System
Supply current	200mA at 12 V
Input	Balanced input
Gain	0,10,20,30,40,50 dB
High Pass Filter	-6db/octave selectable 0, 40, 80, 400,1.6k, 3.2k
Output	2 X Balanced output via 3 pin XLR
Ultra HF Output	2 X Balanced output via 3 pin XLR (with 20kHz high pass filter for porpoise detection)
Headphone	Dual output via ¼" jack
Overall Bandwidth	10Hz-200kHz +/-3dB
GPS	
Input	Serial to USB adapter to interface with ship's NMEA supply
Backup	Standalone USB unit provided as independent backup
Computers	
	Up to date Laptop Computers
Digitisers	
Digitiser	NI USB 6251 high speed Digital Acquisition (if required for porpoise detection)
Sound Card	High quality sound card 192kHz sampling rate e.g. Motu Ultralite Mk3 Hybrid Or RME Fireface 400
Software	
General	PAMGUARD with appropriate configurations
Porpoise Detection	Rainbow Click / Logger

Dan Govier

From:

Chvdn | #Grxjalv# Chvdn | GrxjalvC exhsalqhwp dulqh1frp A

Sent:

P rggd #43 #2 ryhp ehu #5347 # 59 #1 1 1

To:

Gdq#Jrylhu

Cc: Subject: Vip rq#kkghukrxvh IZ #BDP #Vshflifdwirqv#

Attachments:

ESP 0470SDP #wshflilfdwlrqv#8803<0470v4141sqi

Importance:

Kljk

Hi Dan.

Please find below my correspondence with the PAM system for detecting cetaceans.

Senior PAMO) for the TGS survey re the suitability of

Thanks

Sent: Monday, 10 November 2014 9:21 AM

Subject: PAM Specs

Hi

Thanks for the information below. I have used the Vanishing Point PAM system is previous surveys and so am familiar with it and its capabilities — although I acknowledge that PAM systems can be configured differently. Based upon the information you provided to me regarding the PAM specs it's my professional opinion that this system is suitable for detecting the cetacean species likely in the operational area for this survey.

Regards

Sent: Monday, 10 November 2014 8:33 AM

Subject: PAM Specifications

Importance: High

Hi

As part of the MMIA and MMMP processes associated with seismic surveys in New Zealand, the Department of Conservation requires evidence the our Senior PAM Operator confirmed that the PAM system planned to be used is suitable for detection of NZ endemic and vagrant marine mammal species.

Please find attached the specifications of the PAM system we will be using. It is the same system we have used countless times before in NZ. I've pasted below a list of cetaceans likely to be within the operational area of this survey.

Please can you review both and provide your professional assessment as to the suitability of the proposed PAM system.

Table 8: Cetaceans likely to be present in or around the NWF Operational Area

M.	ysticeti (Baleen whale su	iborder)	
Balaenidae (Right whale family)	Baleanoptera (Rorqual family)		
Southern right whale (Eubalaena australis)	Minke whale (Balaenoptera acutorostrata & B. bonaerensis)	Blue whale (Balaenoptera musculus)	
Pygmy right whale (Caperea marginata)	Sei whale (Balaenoptera borealis)	Fin whale (Balaenoptera physalus)	
	Bryde's whale (Balaenoptera edeni)	Humpback whale (<i>Megaptera novaeangliae</i>)	
Odo	ntoceti (Toothed whale s	suborder)	
Delphinidae (Dolp	hin family)	Physeteridae (Sperm whale family)	
Hector's dolphin, Maui's dolphin (Cephalorhynchus hectori; Cephalorhynchus hectori maui)	Dusky dolphin (<i>Lagenorhynchus</i> <i>obscurus</i>)	Sperm whale (Physeter macrocephalus)	
Common dolphin (Delphinus delphis)	Southern right whale dolphin (Lissodelphis peronii)	Pygmy sperm whale (Kogia breviceps)	
Pygmy killer whale (<i>Feresa</i> attenuate)	Killer whale (Orcinus orca)	Dwarf sperm whale (Kogia sima)	
Melon-headed whale (Peponocephala electra)	Spotted dolphin (Stenella attenuata)		
Long-finned pilot whale (Globicephala macrorhynchus)	Striped dolphin (Stenella coeruleoalba)		
Short-finned pilot whale (Globicephala macrorhyncus)	Long-snouted spinner dolphin (Stenella longirostris)		
Risso's dolphin (<i>Grampus</i> griseus)	Rough-toothed dolphin (Steno bredanensis)		
False killer whale (<i>Pseudorca</i> crassidens)	Bottlenose dolphin (Tursiops truncates)		
Zi	ohioidea (Beaked whale	family)	
Arnoux's beaked whale (Berardius arnuxii)	Blainville's beaked whale (Mesoplodon densirostris)	True's beaked whale (Mesoplodon mirus)	
Southern bottlenose whale (Hyperoodon planifrons)	Gray's beaked whale (Mesoplodon grayi)	Shepherd's beaked whale (Tasmacetus shepherdi)	
Andrew's beaked whale (Mesoplodon bowdoini)	Strap-toothed whale (Mesoplodon layardii)	Cuvier's beaked whale (Ziphius cavirostris)	
Pygmy beaked whale (Mesoplodon peruvianus)	Hector's beaked whale (Mesoplodon hectori)		



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APPENDIX 4

Marine Mammal Mitigation Plan for the NWF 2D MSS



Marine Mammal Mitigation Plan:

TGS-NOPEC Geophysical Company – Northwest Frontier Multiclient 2D Marine Seismic Survey

TGS-North-west NZ 2D MSS-BPM-14-MMMP-v1.2 5/11/2014







Document Distribution List

Date: 5/11/2014

Title: Marine Mammal Mitigation Plan: TGS-NOPEC Geophysical Company – Northwest Frontier Multiclient 2D Marine Seismic Survey

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TGS-NOPEC	Barry Grace, TGS Operations	4
EOS Ltd	Dan Govier, Environmental Consultant	5
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		7

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1.1	16/10/2014	Updated with comments	LD	SC	SC
1.2	14/11/2014	Updated with comments from DOC	LD	SC	SC
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Document Reference Number: TGS-North-west NZ 2D MSS-BPM-14-MMMP-v1.2

Prepared by

Last updated: 14 November 2014

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1. Introduction

This document has been developed by Blue Planet Marine (BPM) for TGS-NOPEC Geophysical Company (TGS) in order to meet the requirements for a Marine Mammal Mitigation Plan (MMMP) for the Northwest Frontier Multiclient 2D Marine Seismic Survey (the survey). TGS, a leading geophysical services company, is to undertake a 2D marine seismic survey (MSS) of approximately 17,000 lineal km in the Reinga, New Caledonia and Taranaki Basins.

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 TGS Marine Mammal Impact Assessment (MMIA) developed by Environmental Offshore Services Ltd (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 provides additional and supplemental information useful in the completion of MMO and PAM roles.

2. The TGS-NOPEC Geophysical Company – Northwest Frontier Multiclient 2D Marine Seismic Survey

EOS was engaged by TGS to prepare a MMIA for an approximate 17,000 km survey in the Reinga, New Caledonia and Taranaki Basins, scheduled to commence on 1 December 2014. The survey will be located within the 136,479.5 km² Petroleum Prospecting Permit (PPP) 56377 and will be bound by the survey's Operational Area; (Figure 1). The extent of the Operational Area allows for line turns, acoustic source testing and soft start initiation. Information provided in the draft MMIA for the survey area has been used by BPM in the development of this MMMP.

The survey will acquire data to provide a general understanding of the regional geological structure within PPP 56377 and to identify more prospective areas for further investigations. It is anticipated that the survey will take approximately 4-5 months to complete. Operations will be conducted 24 hours per day, 7 days per week, subject to suitable weather conditions and marine mammal encounters. The seismic vessel, *Aquila Explorer* has been contracted to undertake the survey. The Ocean Pioneer will act as support vessel during the survey.

The Operational Area for the survey is entirely beyond the 12 nautical mile Territorial Sea but within the New Zealand Exclusive Economic Zone. 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. Sections of the eastern side of the Operational Area are within an Area of Ecological Importance (AEI) and so marine mammal mitigation measures in addition to those outlined in the Code will be implemented.

The West Coast North Island Marine Mammal Sanctuary (MMS) extends from Oakura Beach in the south to Maunganui Bluff in Northland and offshore to 12 nautical miles. It was gazetted to protect the 'nationally critical' Māui dolphins. Although the Operational Area does not overlap with the MMS, Māui dolphins (and Hector's dolphins) may be present there.

The Aquila Explorer will tow one solid streamer, 10 km in length which will be at a depth of 8 m at the front and slanted down to 30 m at the end of the streamer The acoustic source will have an effective volume of 4,400 in³ and will be comprised of four subarrays with 10 acoustic sources on all but one of the subarrays, which has nine. The acoustic array will be located at a depth of 8 m below the sea surface and approximately 121 m behind the survey vessel. The depth of the sub-arrays will



ensure 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 source 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 fired at a sourcepoint interval of 25 m apart, where for a typical boat speed of 4.5 knots (kts), relates to a sourcepoint activation every 11 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 sections 4 and 4.5 of this document.

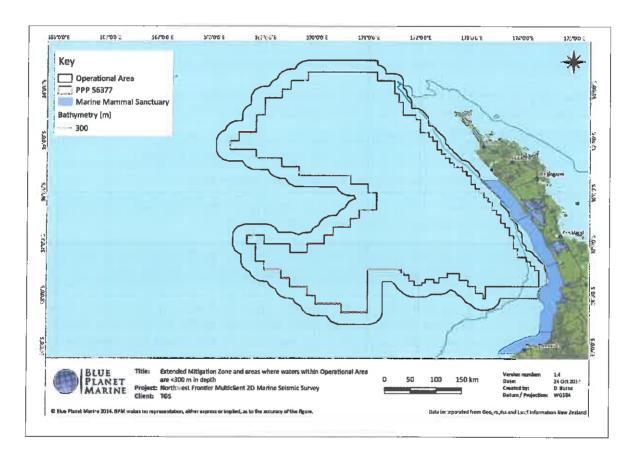


Figure 1: Location of the TGS Northwest Frontier Multiclient 2D Marine Seismic Survey. (Observers to refer to the VADAR system for the coordinates of the Operational Area.)

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.

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, **sext**ant, 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 swing¹.

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 must 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.

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.

It is recommended that observers provide the client with a daily summary detailing marine mammal sightings, mitigation measures taken and instances of non-compliances

The Team leader is responsible for compiling an end of survey summary report based on the data collected throughout each survey. The contents of this report are summarised in Appendix 2 of the Code.

3.1 Māui dolphin sightings

The survey is being acquired mostly in water depths greater than 300 m and located beyond the AEI and West Coast North Island MMS. However, even though the Operational Area is beyond the core range of most Māui dolphin sightings, there is still a possibility one could be observed during the

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



survey. If a Māui dolphin sighting is made during the survey, DOC should be notified as soon as possible.

3.2 Validation of Sound Transmission Loss Modelling (STLM)

Since the survey will be conducted within an AEI, the Code requires that Sound Transmission Loss Modelling (STLM) be undertaken in order to determine if Sound Exposure Levels (SELs) are predicted to exceed those corresponding to the relevant mitigation zones in the Code. For this survey, STLM is based upon the specific configuration of the acoustic array deployed from the *Aquila Explorer* and the environmental conditions within the Operational Area. If STLM predicts that SELs will be exceeded, then consideration will be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly. The Code requires that this STLM be validated during the course of the survey. The MMIA provides the following guidance on this:

"The STLM validation will be undertaken by the Aquila Explorer's Chief Field Geologist and the lead MMO onboard the Aquila Explorer. To complete this validation, SEL's (dB re 1µPa) will be recorded by receivers in the streamer located at four different offsets from the acoustic source; 200 m, 1,000 m, 1,500 m and 2,000 m.² These recordings will take place within the NWF Operational Area and will record SEL's across different depth measurements within the NWF Operational Area, as SEL's are likely to decrease in the deeper waters (Koessler & Duncan, 2014). A heading will be selected along one of the track lines and the test sequence will be performed along this line. In order to confirm and provide a reference to the first suite of results, another test sequence will be performed before the end of the MSS, most likely on the opposite heading."

It is recommended that the MMO Team Leader undertake early communications with the relevant personnel in order to assist with validation of the STLM.

3.3 Contact details for the Department of Conservation

During the survey, the first point of contact within DOC is Ian Angus

If a response is required urgently then telephone but in all other circumstances use email. 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 Ian Angus; 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 TGS (
- TGS to contact EOS (and

² Please note: validation should also be made across the full range of biologically relevant frequencies for marine mammals as described in the Code (i.e. 1 Hz to 180 kHz). If this is not possible using the streamers, other methods may be required.



FOS 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 TGS person) and the Client Reps of the issue and intention to contact DOC, and keep these people informed of discussions and associated events;
- The BPM Project Manager and onshore TGS Project Manager 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 TGS 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.

Note: Based on results of STLM, for a section of the Operational Area TGS is required to implement a mitigation measure amended from that outlined in the Code. For the southeast corner of the Operational Area, where two well ties will be undertaken into water depths of 105 m, the mitigation zone will be increased to 2 km for Species of Concern with or without calf, and to 250 m for other marine mammals. This southeast corner of the Operational Area is labelled the 'Extended Mitigation Zone' and seismic acquisition will occur within this (Figure 2). The 2 km and 250 m mitigation zones will also apply when the seismic vessel enters water depths of less than 300 m within the Operational Area (Figure 2). If the seismic source is active in these areas it will most likely be for soft start or testing of the acoustic source.

It is critical that observers are fully aware of the location of the seismic vessel and source in relation to the Standard and Extended Mitigation Zones and the 300 m depth contour. In order to facilitate this SeaBird Exploration have agreed to supply high resolution monitors linked to the vessel's navigation system. These will show: vessel location in real time; 300 m depth contour; PPP, Operational Area, and Standard and Extended Mitigation Zones. Clear communication as the seismic vessel crosses to and from the Extended Mitigation Zone and into waters of <300 m depth is crucial. At the earliest opportunity, the MMO Team Leader will agree with the relevant vessel and seismic crew clear lines and methods of communication in order to ensure that observers on watch are kept fully informed of the position of the vessel and, thus, are clear on what mitigation zones need to be applied.

Refer to Section 5.1.2.1.2 of the MMIA for details of the STLM. This MMMP is consistent with the Code and MMIA.



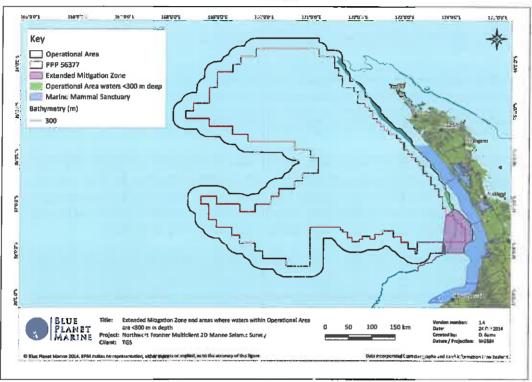


Figure 2: Extended Mitigation Zone and areas where waters within Operational Area are <300 m in depth.

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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 *Aquila Explorer* 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 onboard 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, Addenda 2, and Addenda 3).

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 onboard 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 (and Extended Mitigation Zone) are defined by the coordinates provided in Addenda 4. These have been loaded into VADAR for real time monitoring of vessel location and marine mammal detections relative to the Operational Area and Extended Mitigation Zone.

4.3.2 Operational capacity

The operational capacity of the acoustic source is notified in the MMIA an outlined in Section 2 of this MMMP. This operational capacity should not be exceeded during the survey, except where unavoidable for source testing and calibration purposes only³. 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 stage⁴.

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 ktsWave 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

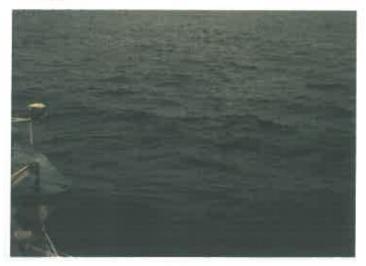
³ D Lundquist, DOC (25 March 2014): "Please note that if the operational capacity is exceeded at any other time (including soft starts), this is a non-compliance incident and should be reported as such."

⁴ D Lundquist, 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 Outline of mitigation procedure

A diagram outlining the general components of the mitigation procedure is shown in Figure 3. Addenda 5 outlines a checklist to be completed by the MMO and/or PAMO on watch prior to the acoustic source being put into the water.

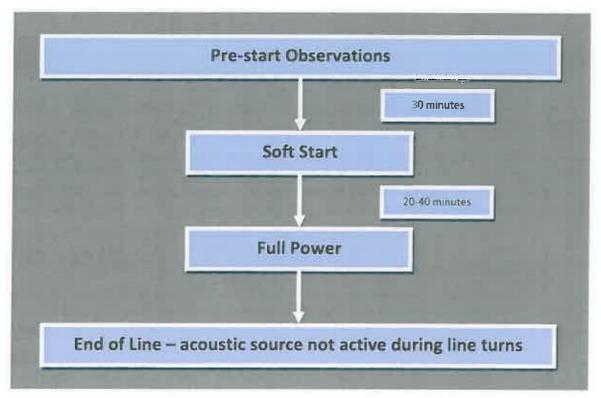


Figure 3: Seismic operations mitigation procedure.



4.3.5 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 if⁵:

⁵ D Lundquist, DOC (25 March 2014): "Please note that this option may only be used if there have not been two hours of good sighting conditions preceding operations. It cannot be used if there were 2 or more hours of good sighting conditions and marine mammals were sighted (i.e., the second option may only be used if weather conditions prevented the first condition being met, not if marine mammal presence prevented the first condition being met)"



- 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 operations⁶, 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.

TGS 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.

4.3.6 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 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 in³) 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).

4.3.7 Line turns

There will be no acquisition during line turns and the acoustic source will not be active.

4.4 Species of Concern

The full list of Species of Concern (SOC) as defined by the Code is shown in Addenda 6 below.

⁶ D Lundquist, DOC (3 November 2014): "... this requirement means that nighttime starts are not allowed, since visual observation cannot be undertaken immediately prior to start-up."



4.5 Mitigation zones

The Code stipulates standard mitigation zones for Level 1 surveys. However, based on the acoustic source to be used and the nature of the survey area, revised (i.e. larger) mitigation zones have been specified for SOC (with or without calf) and for other marine mammals when the seismic vessel enters a designated southeast corner of the Operational Area (labelled the Extended Mitigation Zone) or is within the Operational area in water depths of less than 300 m (Figure 2). Details are outlined in the MMIA (section 5.1.2.1) and a summary (MMIA, Section 2.3.1.3) is provided below:

"When an MSS is undertaken within an AEI, the Code of Conduct 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 Aquila Explorer and the environmental conditions (i.e. bathymetry, substrate, water temperature and underlying geology) within the NWF 2D Operational Area. The Code of Conduct states that if Sound Exposure Levels (SEL's) are predicted to exceed 171 dB re 1μ Pa2.s (behaviour criteria) corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1μ Pa2.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 [MMIA] 5.1.2.1 however, it should be noted that based on the STLM results, the inshore boundary of the survey area has been revised to eliminate the shallowest areas from the NWF 2D MSS. The STLM demonstrated that the shallowest southeast corner of TGS's original Operational Area had the highest SEL's, which decrease as water depth increases [MMIA] (Section 5.1.2.1). As a result, TGS refined the Survey Area and opted to stay beyond the 300 m depth contour except for a well tie line into Tarapunga-1 and Korimako-1 wells."

There are, therefore, two sets of mitigation zones for the survey:

- 1) Standard mitigation zones (SMZ) as outlined in the Code (Figure 4). These apply to the Operational Area in water depths of more than 300 metres. They do not apply within the Extended Mitigation Zone (Figure 5):
 - a. 1.5 km from the centre of the acoustic source for SOC with calf;
 - b. 1.0 km from the centre of the acoustic source for SOC without calf; and
 - c. 200 m from the centre of the acoustic source for all other marine mammals.
- 2) Amended mitigation zones (AMZ) as outlined in the MMIA (Figure 6). These apply to the Extended Mitigation Zone and within the Operational Area where water depth is less than 300 m (Figure 5):
 - a. 2.0 km from the centre of the acoustic source for SOC with or without calf; and
 - b. 250 m from the centre of the acoustic source for all other marine mammals.



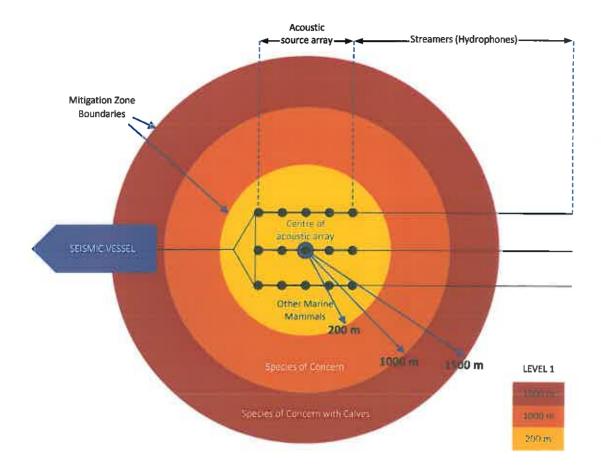


Figure 4: Standard mitigation zones (SMZ) for the survey as outlined in the Code.



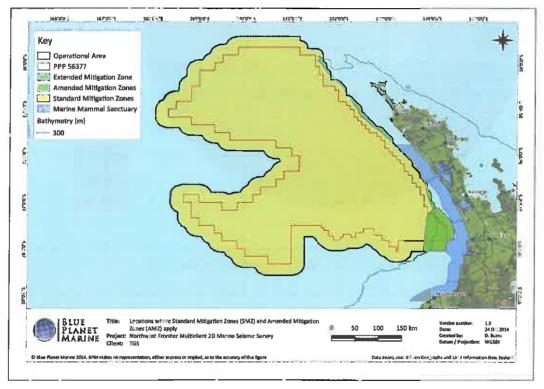


Figure 5: Map showing in which locations the standard mitigation zones (SMZ) and amended mitigation zones (AMZ) apply.

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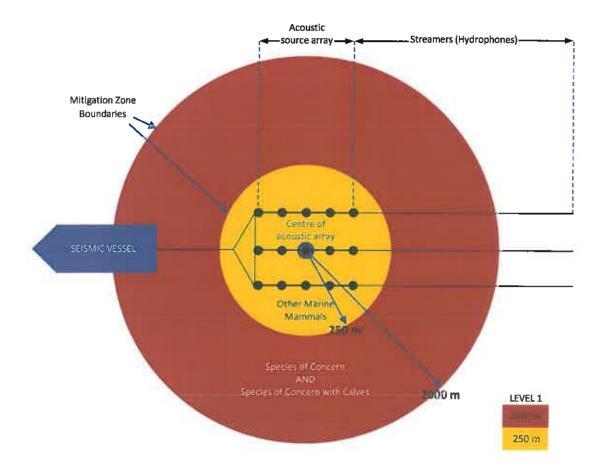


Figure 6: Amended mitigation zones (AMZ) for the survey as outlined in the MMIA.

NOTE: MMOs and PAMOs must be familiar with these two sets of mitigation zones and understand in which locations each applies. Monitors that show vessel location in high resolution will be provided at the MMO and PAMO stations.

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 SMZ or 2.0 km AMZ boundary (as appropriate) 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 SMZ (1.5 km, 1.0 km and 200 m) or the AMZ (2.0 km and 250 m) — as appropriate — 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 (SMZ) or 2.0



km (AMZ) 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 (SMZ) or 2.0 km (AMZ) from the source; or
- Despite continuous observation, 30 minutes has elapsed since the last detection of the group within 1.5 km (SMZ) or 2.0 km (AMZ) 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 DOC⁷: " 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 cetaceans⁸ (<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 (SMZ) or 2.0 km (AMZ). If SOC are approaching these zones, 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 (SMZ) or 2.0 km (AMZ) 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 (SMZ) or 2.0 km (AMZ) from the source; or
- 2) Despite continuous observation, 30 minutes has elapsed since the last detection of the SOC within 1.0 km (SMZ) or 2.0 km (AMZ) 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's 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 (SMZ) or 250 m (AMZ) of the source, start-up will be delayed until:

⁷ Email to BPM from I DOC Senior Adviser - International and Marine; 17 December 2012.

⁸ 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.



- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m (SMZ) or 250 m (AMZ) from the source, or
- Despite continuous observation, 10 minutes has passed since the last detection of a New Zealand fur seal within 200 m (SMZ) or 250 m (AMZ) of the source and 30 minutes has elapsed since the last detection of any other marine mammal within 200 m (SMZ) or 250 m (AMZ) of the source, and the mitigation zone remains clear.

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

Note: The presence of "Other Marine Mammals" within 200 m (SMZ) or 250 m (AMZ) 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 and Addenda 2 of this MMMP for posters detailing mitigation action procedures.

Note: There are two sets of posters for the survey. Addenda 1 outlines mitigation action procedures for the SMZ, while Addenda 2 outlines mitigation action procedures for the AMZ.

5. Further Mitigation Measures

In addition to the amended mitigation zones outlined in section 4.5, the following mitigation measures will be implemented during this survey and are over and above those identified in the Code. They have been agreed by DOC following discussions between TGS and DOC.

1) Additional marine mammal observations outside NWF Operational Area

The Aquila Explorer will travel to the Operational Area from Port Taranaki on mobilisation and demobilisation, as well as for crew changes every five weeks. On transit to and from the 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 Operational Area will be recorded in the 'Off Survey' forms developed by DOC.

2) Necropsy of any stranded marine mammals

If any marine mammals are stranded or washed ashore during the survey inshore of the Operational Area, TGS will engage Massey University to undertake a necropsy to try and determine the cause of death and whether it was a result of any pressure-related or auditory injuries. DOC will be responsible for all aspects of undertaking the necropsy and coordination with pathologists at Massey University; however, TGS will cover the associated costs. TGS will meet these costs for any necropsies required during the survey and for a period of two weeks after the acquisition of the last source-point.



3) 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 is lan Angus

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.

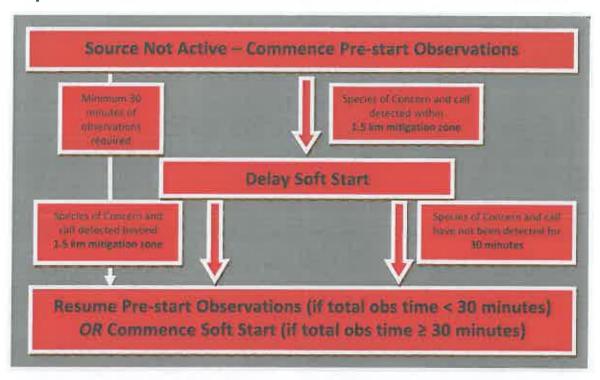
Situation	Timing of notification	Comments
The PAM system becomes non- operational	Immediate	This refers to when both primary and backup systems are non-operational
Any instances of non-compliance with the Code	Immediate	This is a standard requirement under the Code and includes instances where the operational 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
Observation of any dead marine mammals seen in the operational area	As soon as practicable	MMOs should report to DOC as soon as practicable with the time and location of any dead marine mammals seen in the survey Operational Area
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)
Sighting of Māui dolphin	As soon as practicable	DOC is notified via phone as soon as possible with the time and location of the sighting. DOC may mobilise a boat in order to gather a biopsy sample

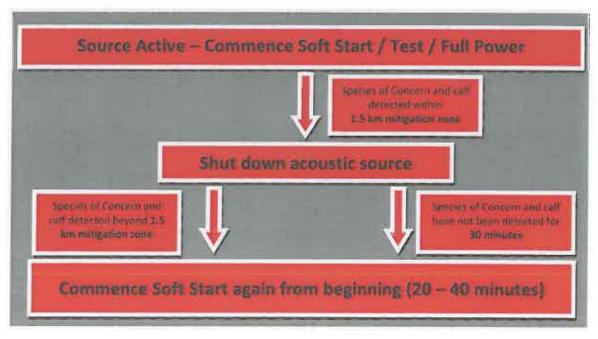


Addenda 1: STANDARD Mitigation Procedures – Good Sighting Conditions (poster format)

Two sets of mitigation zones apply during the survey. The following posters depict mitigation procedures USING STANDARD MITIGATION ZONES (SMZ) AS OUTLINED IN THE CODE. It is recommended these be posted in the instrument room, the PAM station and on the bridge. Operational flowcharts are also found in Appendix 4 of the Code.

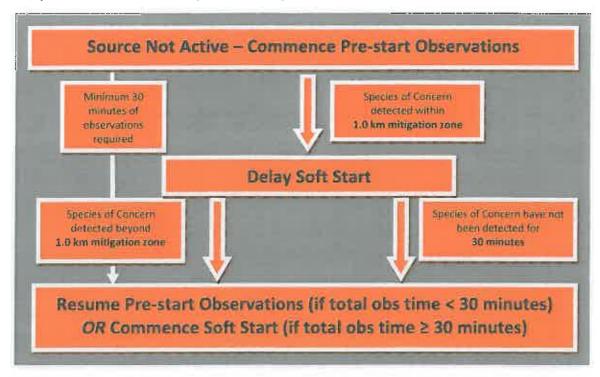
Species of Concern with Calves within 1.5 km of Acoustic Source

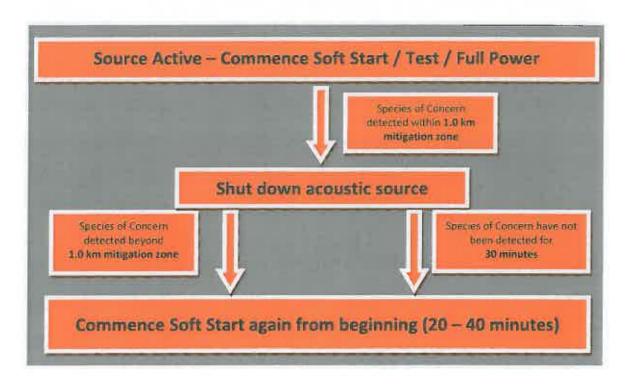






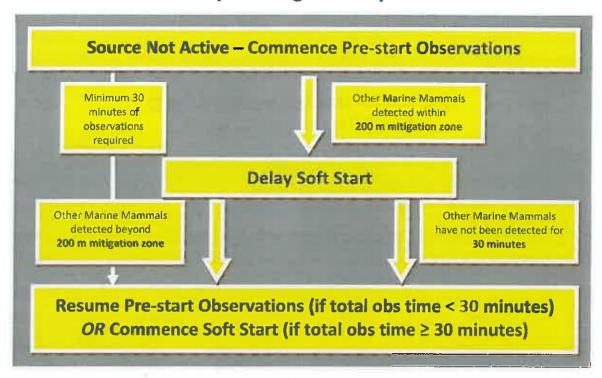
STANDARD MITIGATION ZONES Species of Concern (no Calves) within 1.0 km of Acoustic Source



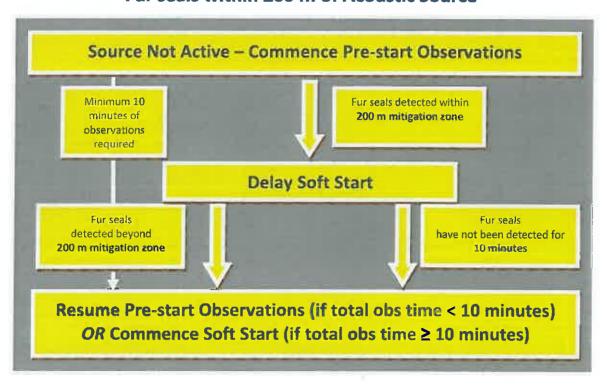




STANDARD MITIGATION ZONES Other Marine Mammals within 200 m of Acoustic Source (excluding fur seals)



Fur seals within 200 m of Acoustic Source

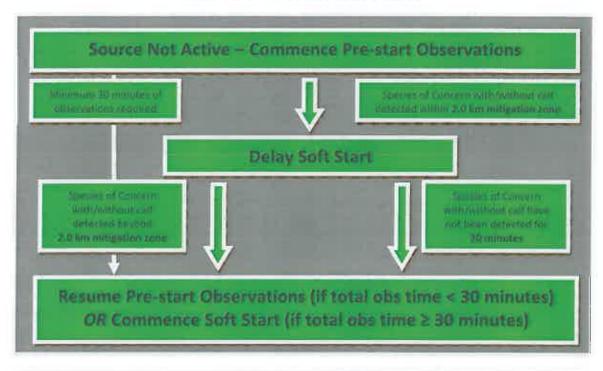




Addenda 2: AMENDED Mitigation Procedures – Good Sighting Conditions (poster format)

Two sets of mitigation zones apply during the survey. The following posters depict mitigation procedures USING AMENDED MITIGATION ZONES (AMZ) AS OUTLINED IN THE MMIA AND THE MMMP FOR THE SURVEY. It is recommended these be posted in the instrument room, the PAM station and on the bridge. Operational flowcharts are also found in Appendix 4 of the Code.

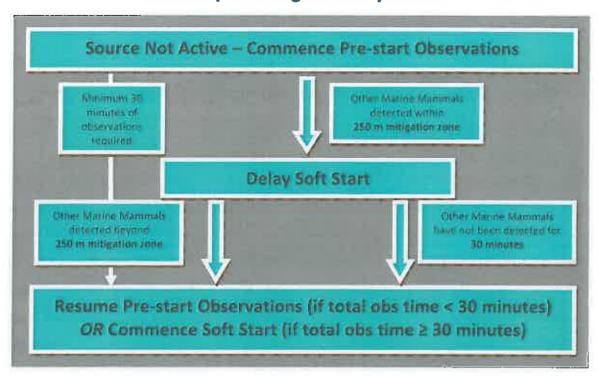
Species of Concern <u>with or without Calves</u> within 2.0 km of Acoustic Source



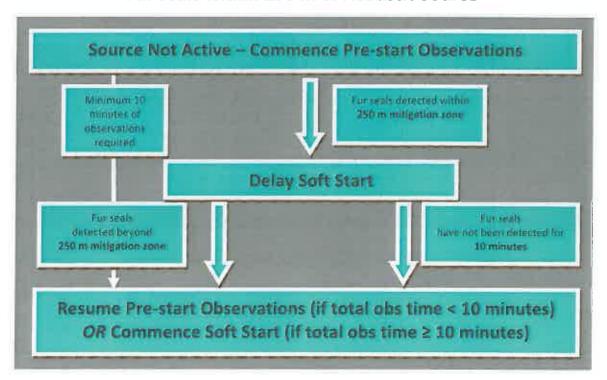




AMENDED MITIGATION ZONES Other Marine Mammals within 250 m of Acoustic Source (excluding fur seals)



Fur seals within 250 m of Acoustic Source

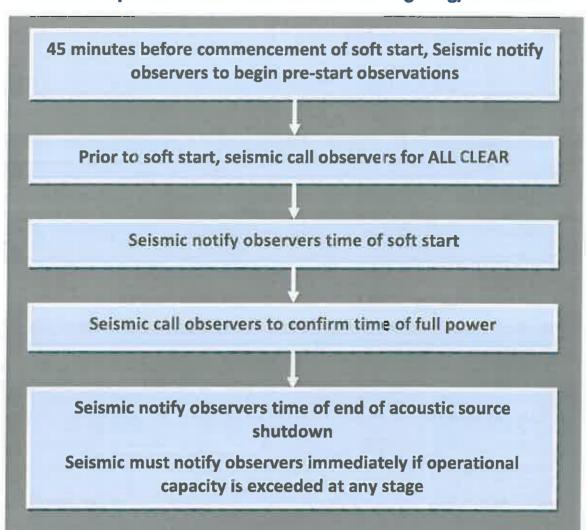




Addenda 3: Recommended Communication Protocols (poster format)

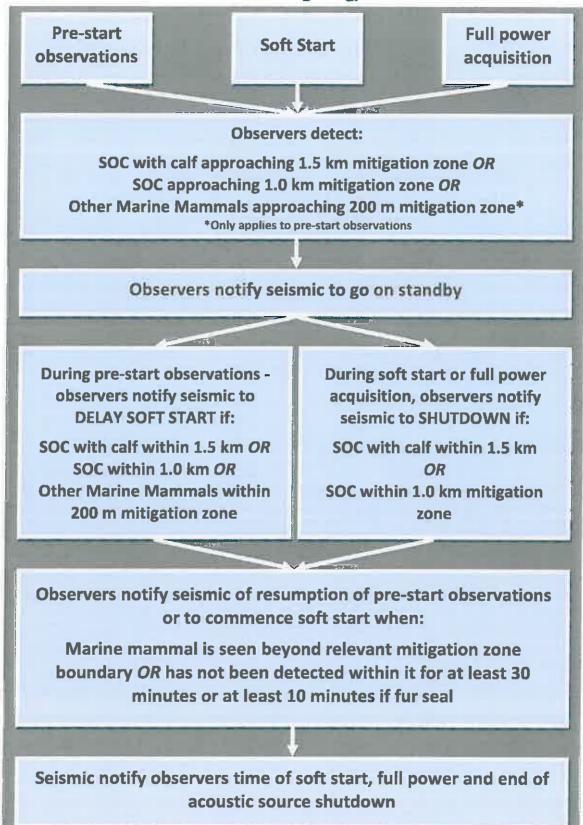
Note: Seismic control room to immediately notify observers (MMO and PAMO) of any changes in the status of acoustic source

Normal Operations - No Marine Mammal Sighting/Detection



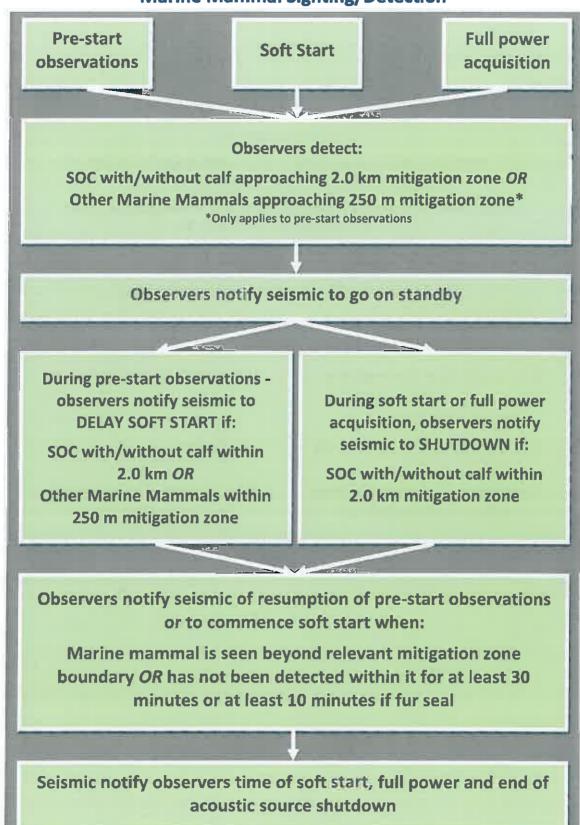


STANDARD MITIGATION ZONES: Delayed Soft Start or Shutdown – Marine Mammal Sighting/Detection





AMENDED MITIGATION ZONES: Delayed Soft Start or Shutdown – Marine Mammal Sighting/Detection





Addenda 4: Operational Area and Extended Mitigation Zone coordinates

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

Operational Area		Extended Mitigation Zone	
Longitude (decimal degrees West)	Latitude (decimal degrees South)	Longitude (decimal degrees West)	Latitude (decimal degrees South)
-38.041790	174.327013	-38.042967	173.828932
-38.042756	173.576393	-37.249998	173.916657
-38.054372	173,576348	-37.114947	174.085346
-38.155093	173.543669	-37.125660	174.149313
-38.233430	173.457030	-37.155031	174.203413
-38.271727	173.341430	-37.214172	174.246152
-38.270497	173.192021	-37.245800	174.295414
-38.236159	173.089507	-37.297555	174.329673
-38.161528	173.002379	-37.353556	174.391714
-38.121441	172.915326	-37.399583	174.442807
-38.020734	172,829806	-37.400558	174.443193
-37.976608	172.749868	-37.403722	174.444521
-37.913657	172.693593	-37.406868	174.445915
-37.880940	172.614374	-37.409995	174.447374
-37.936840	172.542001	-37.413722	174.447294
-37.969077	172.449422	-37.416206	174.447299
-37.971846	172,233724	-37.417301	174.447680
-38.006744	172.162884	-37.420292	174.448308
-38.023811	172.082246	-37.427156	174.449640
-38.022845	171.858434	-37.440900	174.452076
-38.002535	171.775544	-37.457223	174.453838
-37.963364	171.704307	-37.471181	174.454623
-37.857464	171.578397	-37.481473	174.455896
-37.778586	171.527240	-37.490378	174.457761
-37.725676	171.464824	-37.493888	174.458764
-37.725752	171.283713	-37.499961	174.460852
-38.347638	171.285398	-37.503384	174.462238
-38.414092	171.267052	-37.508461	174.464610
-38.473198	171.224292	-37.518370	174.470164
-38.529028	171.141653	-37.540498	174.485409
-38.556509	171.038377	-37.557753	174.496737
-38.554692	170.447184	-37.565039	174.500305
-38.498719	170.305562	-37.566416	174.502061
-38.392103	170.223716	-37.631446	174.501441
-38.389431	169.958325	-37.657057	174.501197



Operational Area		Extended Mitigation Zone		
Longitude	Latitude	Longitude	Latitude	
(decimal degrees West)	(decimal degrees South)	(decimal degrees West)	(decimal degrees South	
-38.346477	169.827978	-37.672653	174.501049	
-38.284478	169.756585	-37.778356	174.500052	
-38.206201	169.718958	-37.779494	174.500041	
-38.133828	169.604189	-37.787431	174.468901	
-38.058557	169.558365	-37.801408	174.433542	
-38.050974	169.427184	-37.819604	174.401348	
-38.009035	169.322259	-37.841551	174.373134	
-37.948450	169.255814	-37.866730	174.349572	
-37.873258	169.220504	-37.894515	174.331253	
-37.813855	169.118754	-37.924237	174.318635	
-37.725276	169.059761	-37.955144	174.312027	
-37.718335	168.930703	-37.986498	174.311615	
-37.678635	168.827753	-38.017506	174.317391	
-37.617276	168.758593	-38.025182	174.320435	
-37.540226	168.721917	-38.041790	174.327013	
-37.495917	168.638050	-38.042967	173.828932	
-37.430979	168.579094			
-37.355317	168.552674			
-37.205639	168.551807			
-37.129962	168.437052			
-37.018012	168.386707			
-36.778856	168.394955			
-36.707863	168.434387			
-36.651859	168.501376			
-36.609462	168.639353	Paulit		
-36.609502	169.030962			
-36.626810	169.111609			
-36.662501	169,182380			
-36.713412	169.236990			
-36.775029	169.270556			
-36.776831	169,538075			
-36.818840	169.666642			
-36.780879	169.768160			
-36.774789	169.896081			
-36.685063	169.955781			
-36.625620	170.058329			
-36.558720	170.087931			
-36.502556	170.141815	-		
-36.450650	170.253807			



Operational Area		Extended Mitigation Zone	
Longitude	Latitude	Longitude	Latitude
(decimal degrees West)	(decimal degrees South)	(decimal degrees West)	(decimal degrees South
-36.351430	170.456924		
-36.291965	170.559523		
-36.182317	170.626694		
-36.141020	170.688220		
-36.115583	170.761640		
-36.058782	170.732084		
-36.052395	170.601436		
-36.013035	170.499363		
-35.959658	170.437216		
-35.892850	170.399579		
-35.882983	169.589138		
-35.824360	169.469145		
-35.725380	169.399922		
-35.718976	169.268318		
-35.679146	169.165979		
-35.625670	169.104405	, and the	
-35.558862	169.067230		
-35.550523	168.760294		
-35.492255	168.638273		
-35.392142	168.567834		
-35.390718	168.305717		
-35.361622	168.195835		
-35.295692	168.108290		
-35.205609	168.063029		
-34.981516	168.060464	THE PARTY AND A PROPERTY AND A PROPE	MATANAMAN AND AND AND AND AND AND AND AND AND A
-34.889243	168.095000		
-34.830401	168.153206		
-34.790805	168.231754	AA bi	
-34.712810	168.269253		
-34.651527	168.338647		
-34.614036	168.436995		
-34.608021	168.560787		
-34.428003	168.575485		
-34.346355	168.634335		
-34.292065	168.728467		
-34.118246	168.735259		
-34.012076	168.802817		
-33.951685	168.918485		
-33.941301	169.072151		
-33.849456	169.132012		



Operational Area		Extended Mitigation Zone	
Longitude	Latitude	Longitude	Latitude
(decimal degrees West)	(decimal degrees South)	(decimal degrees West)	(decimal degrees South
-33.789977	169.235009		
-33.721787	169.265432		
-33.665227	169.320213		
-33.615740	169.429487		
-33.607975	169.573135		
-33.526309	169.622518		
-33.467772	169.706511		
-33.441240	169.829016		
-33.441180	171.164937		
-33.531382	171.168650		
-33.545052	171.237519		
-33.582034	171.292844		
-33.633067	171.323372		
-33.698157	171.328530		
-33.701562	171.536687		
-33.721893	171.591852		
-33.757667	171.634322		
-33.818271	171.661086		
-33.965189	171.662357		
-34.019345	171.726515		
-34.131931	171.745997		
-34.166879	171.795101		
-34.214966	171.823972		
-34.364781	171.829776		
-34.369305	171.958750		
-34.411265	172.039887		
-34.537860	172.153971		
-34.698085	172.163747		
-34.709476	172.232506		
-34.743503	172.289199		
-34.796101	172.324274		
-34.929647	172.473623		
-34.977883	172.495438		
-35.049036	172.497768		
-35.083085	172.546052		
-35.129634	172.575059		
-35.162476	172.625581		
-35.212977	172.658482		
-35.244821	172.708001		
-35.364800	172.819095		



Operational Area		Extended Mitigation Zone	
Longitude (decimal degrees West)	Latitude (decimal degrees South)	Longitude (decimal degrees West)	Latitude (decimal degrees South)
-35.371602	172.885089	,	
-35.397890	172.941627		
-35.546533			
APPLIES TO	173.075860		
-35.589086	173.135595		
-35.641015	173.162622		
-35.716023	173.165754		
-35.832331	173.296455		
-35.880062	173.326559		
-35.915275	173.379532		
-35.963446	173.410067		
-35.998409	173.462793		
-36.046829	173.493576		
-36.091616	173.555209		
-36.142343	173.580594		
-36.216320	173.583440		
-36.364111	173.737314		
-36.466464	173.750626		
-36.605640	173.899578		
-36.716607	173.917822		
-36.753359	173.968728		
-36.803404	173.997211		
-36.966749	174.001698		
-37.027725	174.070282		
-37.114947	174.085346		
-37.125660	174.149313	k ozo zakladan. Aranaklamba na konorma a manda	
-37.155031	174.203413		
-37.214172	174.246152		
-37.245800	174.295414		
-37.297555	174.329673		
-37.399476	174.442764		
-37.400558	174.443193		
-37.403722	174.444521		
-37.406868	174.445915		
-37.409995	174.447374		
-37.413722	174.447294		
-37.416206	174.447299		
-37.417301	174.447680		
-37.420292	174.448308		
-37.427156	174.449640		
-37.438478	174.451762		



Operational Area		Extended Mitigation Zone	
Longitude	Latitude	Longitude	Latitude
(decimal degrees West)	(decimal degrees South)	(decimal degrees West)	(decimal degrees South
-37.440692	174.452092		
-37.440707	174.452092		
-37.440900	174.452076		
-37.457223	174.453838		
-37.471181	174.454623		
-37.481473	174.455896		
-37.490378	174.457761		
-37.493888	174.458764		
-37.499961	174.460852		
-37.503384	174.462238		
-37.508461	174.464610		
-37.513454	174.467263		
-37.518370	174.470164		
-37.551256	174.492825		
-37.557753	174.496737		
-37.565039	174.500305		
-37.779491	174.500050		
-37.787431	174.468901		
-37.801408	174.433542		
-37.819604	174.401348		
-37.841551	174.373134		
-37.866730	174.349572		
-37.889481	174.334573		
-37,894515	174.331253		
-37.924237	174.318635		
-37.955144	174.312027		
-37.986498	174.311615		
-38.017506	174.317391		
-38.025182	174.320435		
-38.041790	174.327013		



Addenda 5: Checklist for MMOs and PAMOs before acoustic source is put into water

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

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

	Task	Confirmed by? (MMO &/or PAMO)
1	Establish communications protocol with seismic control room and between MMO and/or PAMO on watch and ensure these are functioning	
2	Ensure MMOs, PAMOs and seismic control room are aware that the acoustic source must not enter the water within the Operational Area without MMO (daylight hours) and PAMO (24 hours) on watch	
3	Is seismic control room aware that they need to inform MMO and/or PAMO at what time they intend to place seismic source into the water?	
4	MMO (daylight hours) informs PAMO that they are on watch prior to acoustic source being placed in water and endorses go ahead for acoustic source to be placed in water	
	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	
	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.	
	Seismic control room acknowledged this?	
	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 6: 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 whal e	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
ong-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
ygmy killer whale	Feresa attenuata
Pygmy right whale	Caperea marginata
Pygmy sperm whale	Kogia breviceps
ei whale	Balaenoptera borealis
hepherd'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



Centre for Marine Science and Technology

Received underwater sound level modelling for the Northwest Frontier Seismic Survey, New Zealand

Prepared for:

Environmental Offshore Services Ltd

PROJECT CMST 1329 REPORT 2014-33

23rd July 2014

Summary

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from seismic survey operations within the 2D Northwest Frontier survey area and the 55781 exploration permit area. The modelling method used to produce these results accurately deals with both the horizontal and vertical directionality of the airgun array, and with water column and seabed variations in depth and range.

Within the 55781 permit area, two array configurations were modelled. Sound exposure levels from the Aquila 4400 cubic inch array and the Nucleus 4140 cubic inch array were predicted to be below the threshold of 186 dB re 1 μ Pa².s at 200 m and below 171 dB re 1 μ Pa².s at 1 km. Levels produced by the 4140 cubic inch array were predicted to be between 1 and 3.5 dB lower than those produced by the 4400 cubic inch array depending on range.

Modelling also predicted that operations in the shallowest waters (70 m) present in the Northwest Frontier survey area will produce maximum sound exposure levels of 188.2 dB re 1 μ Pa².s at 200 m and 176.3 dB re1 μ Pa².s at 1 km. These levels drop below thresholds of 186 dB re 1 μ Pa².s and 171 dB re 1 μ Pa².s at ranges of 270 m and 2.24 km respectively. The sound exposure levels in general become lower as water depth is increased. At 300 m and greater water depth levels are below 186 dB re 1 μ Pa².s at 200 m range and below 171 dB re 1 μ Pa².s at 1 km range.

Long range sound exposure level predictions were highly directional due to a combination of airgun array directionality and variable bathymetry. Over long ranges the levels undergo moderate attenuation rates for inshore propagation and slow attenuation for offshore propagation. For a seismic source in the south-eastern corner of the North-western Frontier survey area, in 97 m of water, 20 km from the outer boundary of the West Coast North Island Marine Mammal Sanctuary, the maximum levels produced at the boundary were predicted to be 145 dB re 1 μ Pa².s.

Restricting the source to deeper water markedly reduced the inshore sound levels. A source in 300m of water, 26 km from the outer marine mammal sanctuary boundary was predicted to produce maximum levels of 127 dB re 1 μ Pa².s at the boundary.

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1 Introduction

This report describes acoustic propagation modelling which was carried out to predict received sound exposure levels from the 2D Northwest Frontier seismic survey in order to establish whether the survey meets 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. The Code requires modelling to determine whether received sound exposure levels will exceed 186 dB re 1 μPa^2 .s at range of 200m from the source, or 171 dB re 1 μPa^2 .s at ranges of 1km and 1.5km.

The survey spans the offshore area of New Zealand's North Island from Reinga Ridge in the north to Waikato-Taranaki region in the south. As part of this modelling work two survey areas were considered: the Northwest Frontier survey and a smaller survey area in exploration permit area 55781. The bounding polygons are shown in Figure 1. Figure 2 shows the sail lines for both survey areas and the boundaries of the West Coast North Island Marine Mammal Sanctuary are also plotted.

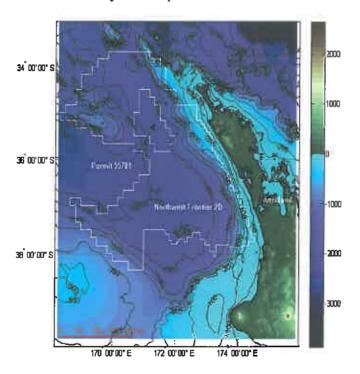


Figure 1. Map of the New Zealand North Island showing Northwest Frontier and permit 55781 survey areas.

The white polygon shows the bounds of the surveys.

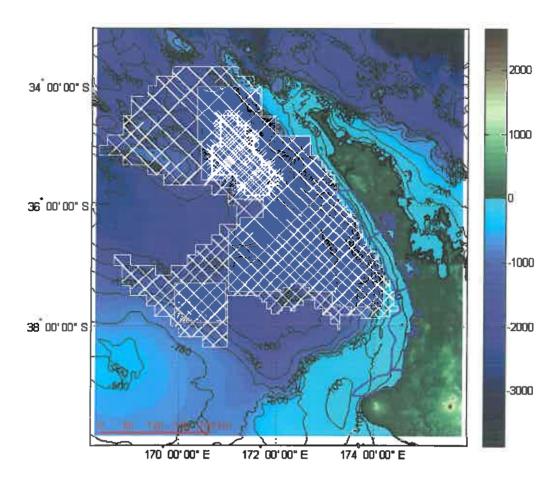


Figure 2. Map the New Zealand North Island showing Northern Frontier and permit 55781 survey areas showing survey sail lines. The blue bounding polygon is a marine sanctuary area.

The Northwest Frontier survey area covers a large geographic footprint. The offshore environment transitions from the continental shelf through the continental slope to benthic regions, and the active past geologic regime around New Zealand introduces some major geographic and geological features into the environment. As such, the offshore region within the Northwest Frontier seismic survey and the surrounding area is geographically and geologically complex. With a smaller geographic footprint, most of the 55781 survey area is in deep water with minor bathymetric complexity. The bathymetry data shown in Figure 1 and Figure 2 were obtained from the NIWA elevation and bathymetry grid (CANZ 2008).

This report details the sound propagation modelling of transmitted signals from two proposed airgun array configurations operating in the 55781permit area and one airgun array configuration operating in the encompassing Northwest Frontier area. Sound exposure levels were then calculated from these signals. The propagation modelling includes the complex environmental factors likely to be found within the survey region. 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 two airgun arrays proposed for this survey are the Aquila 4400 cubic inch array and the Nucleus 4140 cubic inch array shown in Figure 3 and Figure 4.

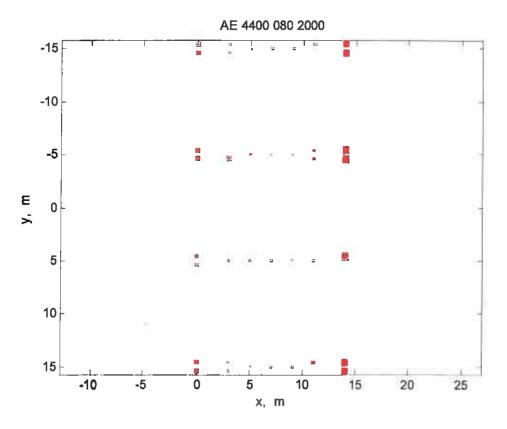


Figure 3. Plan view of the Aquila 4400 cui array. Array elements are shown much larger than actual size but are scaled proportional to the cube root of their volume.

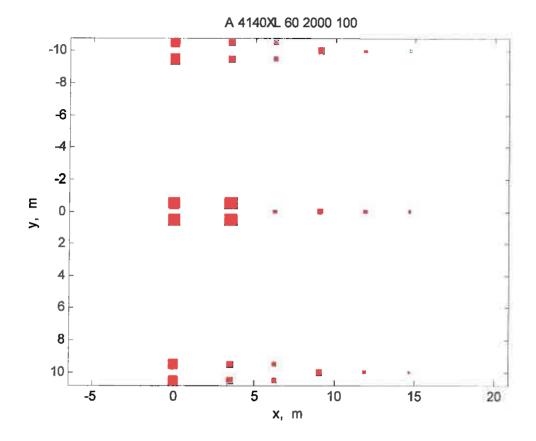


Figure 4. Plan view of the Nucleus 4140 cui array. Array elements are shown much larger than actual size but are scaled proportional to the cube root of their volume.

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 in³ 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:

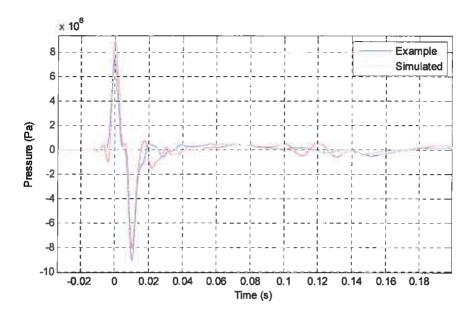
- The distances from each gun to a point in the far-field along the required azimuth were calculated. (The far-field is the region sufficiently far from the array that the array can be considered a point source);
- The corresponding time delays were calculated by dividing by the sound speed;
- Computed 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 μ Pa²s/Hz @ 1m.

2.1.3 Source modelling results

Figure 5 and Figure 6 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 8 m (for calibration only) for the Aquila Array and 6 m for the Nucleus array. These depths were used for array calibration. The CMST airgun model accounts for the effects of the resulting increase in hydrostatic pressure on the oscillation of the airgun bubbles, and hence on the radiated sound.



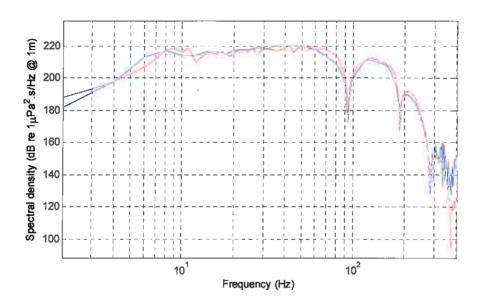
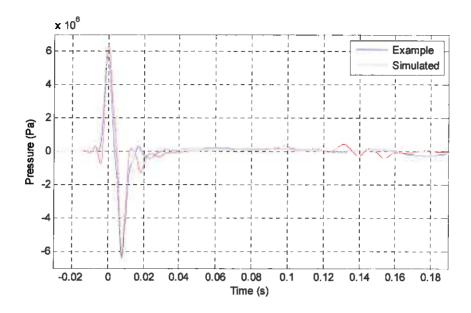


Figure 5. Comparison between the waveforms (top) and spectra (bottom) for the Aquila 4400cui array. The example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).



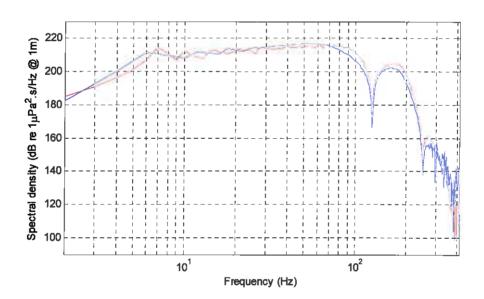


Figure 6. Comparison between the waveforms (top) and spectra (bottom) for the Nucleus 4140cui array. The example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).

Vertical and horizontal cross-sections through the frequency dependent beam pattern of the array are shown in Figure 7 and Figure 8 for the Aquila 4400cui array and Nucleus 4140cui array respectively. 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 airgun array with wide spacing between elements or in this case wide spacing between sub-arrays.

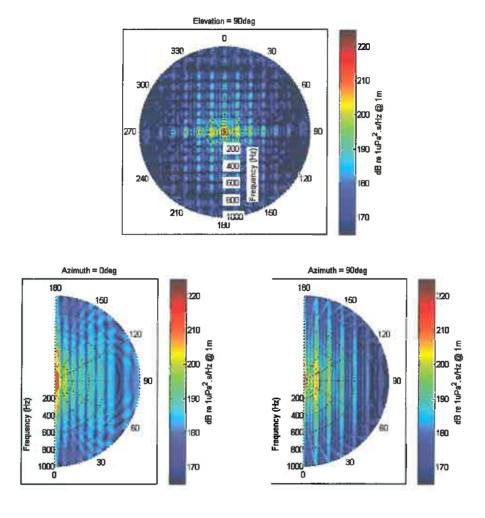
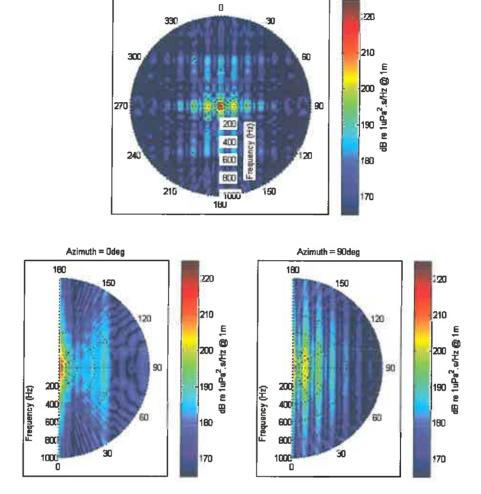


Figure 7. Array far-field beam patterns (Aquila array) as a function of orientation and frequency. The top plot is for the horizontal plane with 0 degrees azimuth corresponding to the in-line direction. The bottom two plots are for the vertical plane for the in-line direction (left) and cross-line direction (right). Zero elevation angle corresponds to vertically downwards.



Elevation = 90deg

Figure 8. Array far-field beam patterns (Nucleus array) 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

Figure 9 shows a comparison between sound speed profiles for this region calculated from temperature and salinity data from the World Ocean Atlas (Antonov, Locarnini, Boyer, Mishonov, & Garcia, 2006; Locarnini et al., 2006). These data are averages over three month blocks: January to March (summer), April to June (autumn), July to September (winter) and October to December (spring). There is a strong seasonal thermocline in the

upper part of the water column that results in a downwardly refracting near-surface sound speed profile in spring and summer, a weak surface duct in autumn, and a strong surface duct in winter. As a result a near-surface acoustic source such as an airgun array would be expected to produce its lowest long range levels in spring and summer, moderate levels in autumn, and its highest levels in winter. The autumn sound speed profile 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 10.

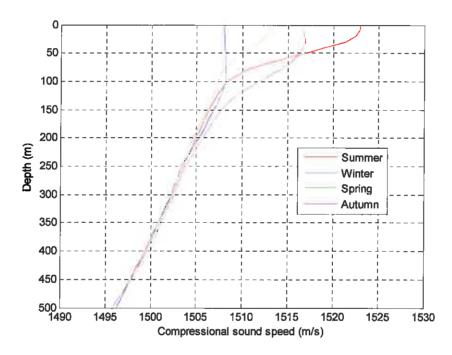


Figure 9. A comparison between sound speed profiles derived from data from the nearest grid point of the World Ocean Atlas (2005) for different southern hemisphere seasons.

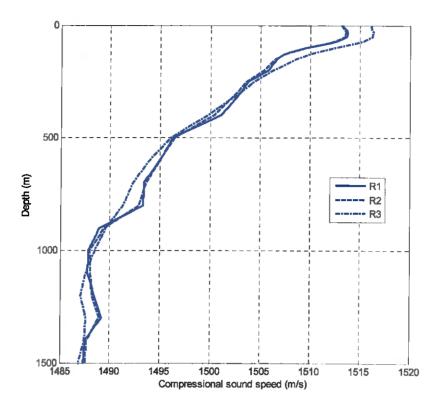


Figure 10. Sound velocity profiles obtained from NOAA World Ocean Atlas.

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 11. The regions were chosen to represent the probable bottom sediment compositions and subbottom layering. The bottom models for each region were based on information from published literature on New Zealand regional seabed geology and the acoustic properties of marine sediments. For the R1, R2, and R3 regions, 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 R4 and R5 regions, an equivalent fluid bottom was used rather than an elastic bottom. For long range propagation this is a reasonable approximation. The resulting seabed properties for each geoacoustic region are tabulated below in Table 1.

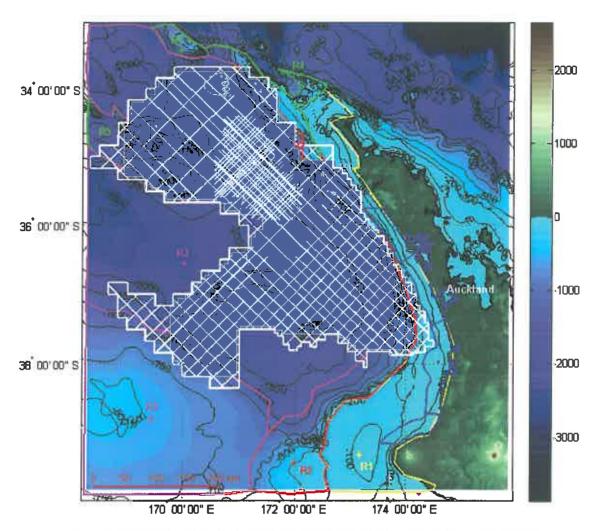


Figure 11. Geoacoustic regions for the Northwest Frontier 2D seismic survey region and the PP 55781 region. The boundary of the West Coast North Island Marine Mammal Sanctuary is plotted in dark blue.

Table 1: Geoacoustic Properties for the regions in defined in Figure 10

Layer Sediment	Thickness (m)	ρ (kg.m ⁻³)	с _р (m.s ⁻¹)		α_p (dB/ λ)		
Description		(Kg.III)					
	R1: Taranal	ki - Northland Con	tinental S	helf			
[Fine Sand]							
Fine Sand Layer	150	1856	1'	700	(0.8	
		2030	1844				
Fine Sand Half Space	N/A	2030	1844		0.8		
	R2: Taranak	si - Northland Cont [Silt - Clay]	tinental SI	оре			
Silt – Clay	150	1488	15	549	0.1		
Layer		1662	1733				
Silt – Clay Half Space	N/A	1662	1733		0.1		
	v Caledonia Basin	- Reinga Basin - Cl (Mud-Oozes)]	hallenger l	Plateau [F	elagic Sec	liments	
Pelagic Plain Mud -	400	1421	1520		0.1		
Ooze		1886	2011				
Mud - Ooze	N/A	1886	2011		0.1		
Half Space	D4: Varing Ma	iner Frature 7	Delana	D:1			
		inez Facture Zone arbonate Sediment	_	Kidge			
			C _p	C _s	a _p	a,	
			(m.s ⁻¹)	(m.s ⁻¹)	(dB/λ)	(dB/λ)	
Carbonate	N/A	1900	2100	550	0.1	0.2	
Sediment Half Space							
Equivalent Fluid	N/A	1900	2290	0.0	7.6	0.0	
Half Space							
		lk Ridge - Wangan entary Rock (Lime		;			
Limestone Half Space	N/A	2400	3000	1500	0.1	0.2	
Equivalent Fluid Half Space	N/A	2400	1385	0.0	10.6	0.0	

Symbol key for Table 1:

 ρ = density, c_p = compressional wave speed, c_s = shear wave speed, α_p = compressional wave attenuation, α_s = shear wave attenuation, λ = wavelength

The Northwest Frontier survey area spans the southwest Pacific back arc complex associated with previous rifting-subduction events as part of the later stages of the opening of the Tasman sea (Bache et al., 2012). The offshore region is composed of

linked sedimentary basins, ridge systems intersected by the New Zealand land mass (C. I. Uruski, 2010). The onshore area is composed of a shelf-slope system with varied amounts of terrestrial sediments (Carter, 1975; Griffiths & Glasby, 1985). There are also local patches of carbonate sediments that become more common in the Northern area of the survey.

The bottom sediments of the continental shelf and continental slope within the Northland-Waikato-Taranaki regions consist of detrital terrigenous sediment (Carter, 1975, 1980). On this section of the continental shelf, the sediment types can range from coarse siliceous sand near shore, and fine sand at the shelf break (Carter, 1980). The detrital sediments are further transported down the continental slope. Silts and clays that grade to mud are predominantly deposited on the continental slope. In general, sediments become finer away from the continental shelf to the lower areas of the pelagic areas of the Southern New Caledonia Basin (Collot et al., 2008), Reinga Basin (Bache, Stagpoole, & Sutherland; Bache et al., 2012; R. H. Herzer et al., 1997), and Challenger Plateau (Andrews & Eade, 1973). As such the R1, R2, and R3 regions represent this fining trend from the near shore to offshore areas.

The sediment thickness of continental shelf and slope of the South Taranaki basin has been estimated at an average thickness of 150 m by Nodder (1995). This thickness was assumed to continue northward into the Northwest Frontier survey area. Seismic surveys discosued in C. Uruski and Wood (1991) indicate that sediments packages within the Southern New Caledonia Basin are 400-500 m thick. The regions R1 and R2 were modelled with a 150 m thick sediment layer and R3 with a 400 m thick layer.

The northernmost extent of the inshore Northern Fortier survey is absent of any major river system (Griffiths & Glasby, 1985), and current and relic carbonate sediments dominate on the seafloor (Carter, 1975). These sediments are composed of carbonate grains; clasts range from gravel to sand sizes (Summerhayes, 1969a, 1969b). The R4 region represents this bottom type and spans the Vening Meinez Facture Zone and Reinga Ridge off the Northland Cape.

R5, defines the Norfolk and Wanganella Ridge area. Seismic cross-sections show basement rock outcropping at the seafloor and collected dredge samples contained mostly limestone rock (R. Herzer & Mascle, 1996; R. H. Herzer et al., 1997; R. H. Herzer et al., 1999). The bottom type for the R5 region was therefore chosen as limestone.

With the likely bottom sediment types defined for the offshore area, the geoacoustic parameters for the regions R1 – R3 were taken from Hamilton (1980). For layers of unconsolidated sediments compaction and resulting porosity reduction can change the sound propagation parameters within a layer (Jensen et al., 2011). Therefore, a gradient between the top and the bottom of the sediment layer for the regions R1, R2, and R3 was used. Both the compressional wave speed (Hamilton, 1979) and density (Hamilton, 1976) were increased linearly with depth within these layers.

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. For the limestone bottom of R5, the geoacoustic parameters were taken from Jensen et al. (2011). A fluid bottom replaced the elastic parameters of limestone and calcarenite bottoms of R4 and R5. The properties of respective fluid half spaces were chosen, calculating a fluid reflection coefficient and matching it as closely as possible to the solid bottom reflection coefficient. The reflection coefficient fits are shown in Figure 12 and Figure 13. Fluid bottoms are required to facilitate the use of RAMGeo as a sound propagation code for long range modelling.

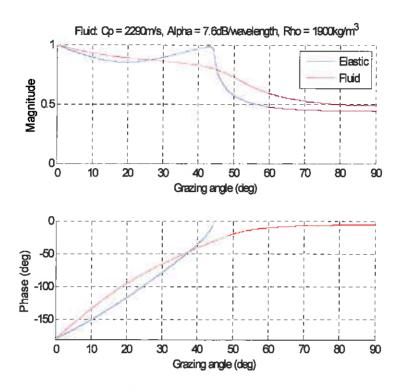


Figure 12. Equivalent fluid bottom for R4.

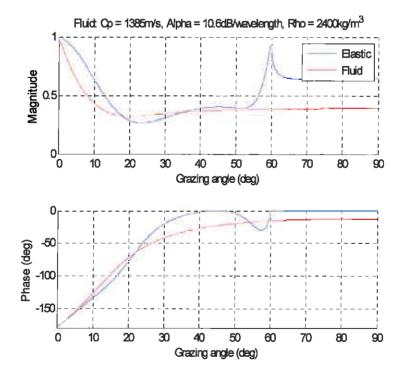


Figure 13. Equivalent fluid bottom for R5.

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 placed with the 55781 area to compare levels produced from the 4400cui and 4140cui arrays. Source locations S3, S4, S5, and S6 were chosen to model the short range sound propagation in various water depths and over various bottom types. The source locations are shown in Figure 14 and Figure 15. These locations were chosen to model various scenarios where the greatest amount of sound energy would propagate in the ocean.

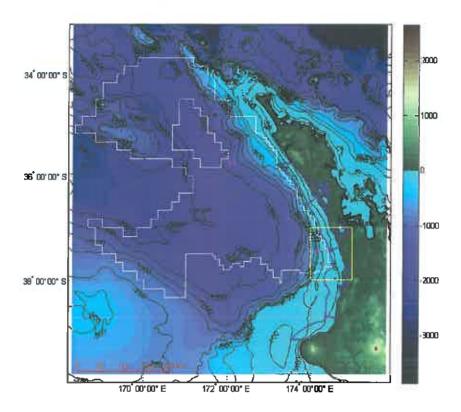


Figure 14. S1 is the source location chosen for short range modelling within PEP 55781. The other source locations are within the yellow rectangle, which is shown in more detail in Figure 15. The inner white polygon is the boundary of PEP 55781. The outer white polygon is is the Northwest Frontier 2D survey boundary. The dark blue line is the boundary of the West Coast North Island Marine Mammal Sanctuary.

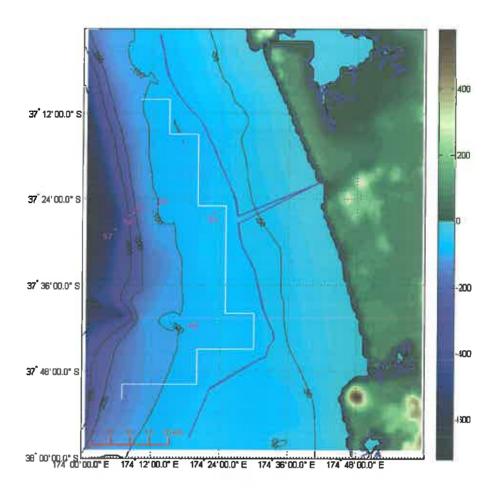


Figure 15. Zoomed view of the region bounded by the yellow rectangle in Figure 14 showing the source locations in the southeastern corner of the survey area used for short range modelling (S3 to S7), and for long range modelling (S2 and S6). The white line is the Northwest Frontier 2D survey boundary. The dark blue line is the boundary of the West Coast North Island Marine Mammal Sanctuary.

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 S2 and is shown below in Figure 16. This location was chosen as being likely to produce the highest sound levels inshore of the survey area and within the marine sanctuary area.

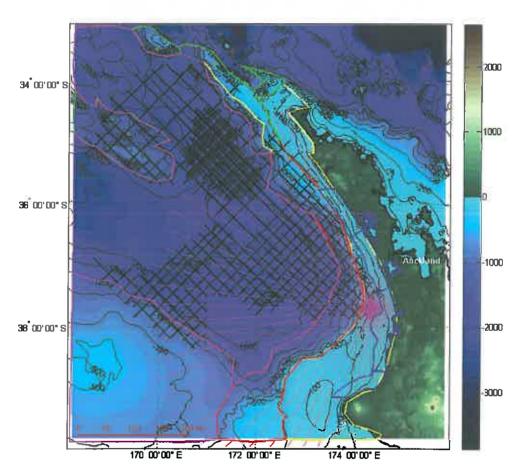


Figure 16. Geoacoustic regions, marine sanctuary area, and source location (S2) used for long-range modelling. The boundary of the West Coast North Island Marine Mammal Sanctuary is plotted in dark blue.

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 airgun array, 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 airgun array (8 m for the 4400cui array, 6m for the 4140cui array). 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 at 5° azimuth increments out to 400 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. For the northwest corner of the survey a 2.5° azimuth increment was used. 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 308°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 5° and 2.5° 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 1/3rd-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 for the 4140cui and 4400cui arrays are plotted as a function of range and azimuth from the source at S1 in Figure 17. The directionality of received levels in the horizontal plane is due to the directionality of the airgun array, which produces its highest levels in the cross-line and in-line directions.

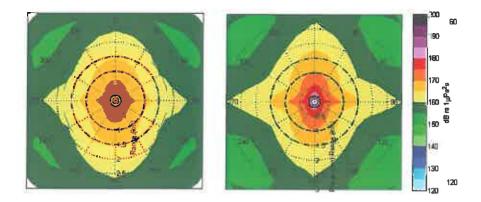


Figure 17. Predicted maximum received SEL at any depth produced by the 4140 cui array (left) and the 4400cui array (right) as a function of azimuth and range from the source (autumn sound speed profile). An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

Figure 18 shows a point plot that compares sound exposure levels produced by the two arrays at S1 as a function of range. The maximum predicted sound exposure levels at the specified mitigation ranges for a seismic survey vessel operating within the PEP 55781 permit area are as listed in Table 2.

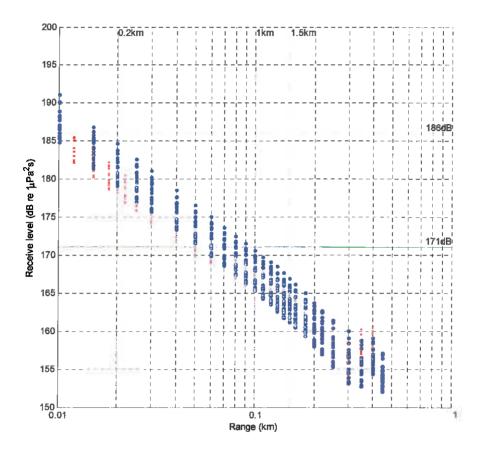


Figure 18. Scatter plot of maximum SEL produced by the Aquila 4400cui array (blue dots) and the Nucleus 4140 cui array (red crosses) at S1. Points are maximum predicted received levels at any depth as a function of range, plotted for all azimuths. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 μ Pa².s (solid) and 186 re 1 μ Pa².s (broken).

Maximum Sound Exposure Level (dB re 1 μPa ² .s)			
Aquila 4400cui	Nucleus 4140 cui		
184.7	181.2		
170.6	168.5		
166.8	165.5		
	Aquila 4400cui 184.7 170.6		

Figure 19 shows the maximum SEL at any depth as a function of range and azimuth for a source at S3, and Figure 20 shows the corresponding point plot of SELs. These results show consistently higher SELs than the corresponding results for S1. This is a consequence of S3 being in much shallower water than S1 and over an acoustically reflective seabed.

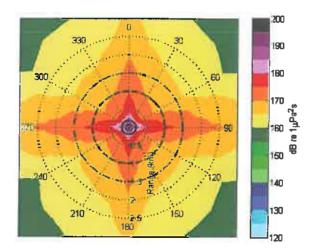


Figure 19. Predicted maximum received SEL at any depth (autumn sound speed profile) as a function of azimuth and range from the source to a range of 2.5km for the Aquila 4400cui array at S3. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

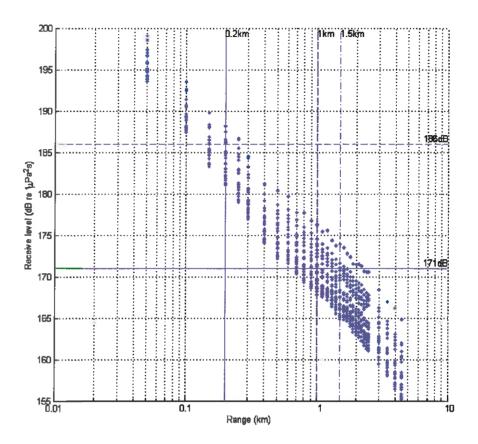


Figure 20. Scatter plot of maximum SEL produced by the Aquila 4400cui array at S3 (autumn sound speed profile). Blue dots are maximum predicted received levels at any depth as a function of range, plotted for all azimuths. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 μPa².s (solid) and 186 re 1 μPa².s (broken).

Given the high predicted SELs at S3, source locations S4, S5, S6 and S7 were chosen in locations with increasing water depths so that the water depth at which received levels would decrease below 186 dB re 1 μ Pa².s at 200 m and below 171 dB re 1 μ Pa².s at 1 km could be determined. Table 2 presents these results.

Figure 21 shows a scatter plot of the maximum predicted SEL at S3, S4, S5, S6, and S7 as a function of range. The different coloured dots represent SEL at different ocean water depths. Table 3 summarises these results, tabulating the SELs at ranges of 200 m, 1 km and 1.5 km.

Table 3: Maximum SEL at 200m, 1km, 1.5km ranges

	SEL at 200 m	SEL at 1 km	SEL at 1.5 km	
	(dB re 1 μPa ² .s)	(dB re l μPa ² .s)	(dB re 1 μPa ² .s)	
S3 (H = 70.7 m)	188.2	176.3	173.9	
S4 (H = 100 m)	187.5	174.7	172.4	
S5 (H = 220 m)	186.3	173.3	168.9	
S6 (H = 300m)	184.9	170.5	169.3	
S7 (H = 494m)	184.7	169.3	166.6	

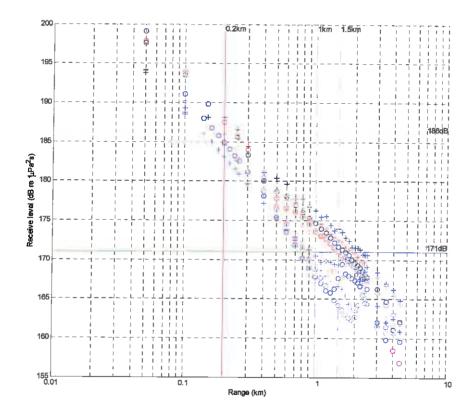


Figure 21. Scatter plot of SEL in the cross-line direction (crosses) and in-line direction (circles) produced by the Aquila 4400cui array at source locations S3 (black), S4 (red), S5 (brown), S6 (blue) and S7 (magenta). Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dashdot). Horizontal green lines show mitigation thresholds of 171 dB re 1 μ Pa².s (solid) and 186 re 1 μ Pa².s (broken).

	Range (m) where SEL< 186	Range (m) where SEL< 171
	dB re 1 μPa ² .s	dB re 1 μPa².s
S3 (H = 70.7 m)	270	2240
S4 (H = 100 m)	250	1970
S5 (H = 220 m)	210	1290
S6 (H = 300m)	175	940
S7 (H = 494m)	180	835

Table 2: Ranges at which SEL is predicted to drop below thresholds in shallow water

3.1.2 Long Range Modelling Results

Figure 22 shows the geographical distribution of received sound exposure levels out to a maximum range of 400 km from source location S2, which is in 97m of water. Figure 23 shows the same data to a maximum range of 80 km. 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 marine mammal sanctuary boundary for a source at S2 are predicted to be 145 dB re $1 \mu Pa^2$.s.

Restricting the source to deeper water markedly reduces the inshore sound levels. This can be seen in Figure 24 which shows the predicted sound exposure levels due to a source on the 300m depth contour at S6 out to a maximum range of 80 km. Maximum received levels at the outer marine mammal sanctuary boundary in this case are predicted to be 127 dB re 1 μ Pa².s, so although S6, at a distance of 26km, is only slightly further from the sanctuary boundary than S2 (20km), the greater water depth at the source and steeper seabed slope results in received levels that are 18 dB lower.

The strong and complicated directionality apparent in these plots is due to a combination of the directionality of the array, which produces maxima in the in-line and cross-line directions and the effects of bathymetry. The effect of variable bathymetry causes rapid attenuation upslope from the source and enhances propagation downslope. Upslope from the source, rays steepen on each subsequent seabed reflection, increasing the attenuation rate. Conversely in the downslope direction rays are flattened on each subsequent seabed

reflection, which reduces the number of seabed interactions and therefore the attenuation rate.

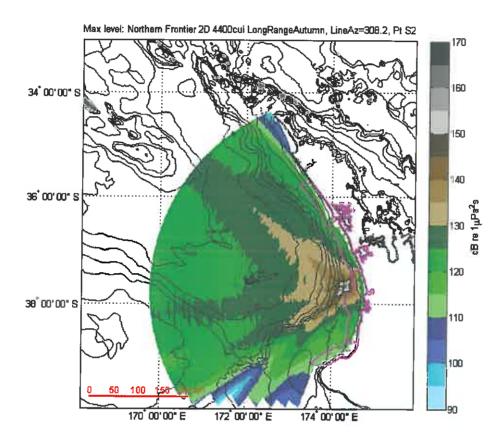


Figure 22. Geographical distribution of modelled sound exposure level for a source at S2 to a maximum range of 300km - autumn sound speed profile. (Maximum level at any depth.) Survey line azimuth is 308°T. The boundary of the West Coast North Island Marine Mammal Sanctuary is plotted in magenta.

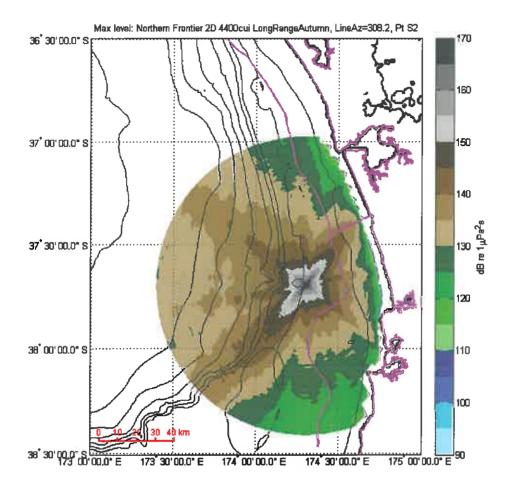


Figure 23. Geographical distribution of modelled sound exposure level for a source at S2 to a maximum range of 80km - autumn sound speed profile. (Maximum level at any depth.) Survey line azimuth is 308°T. The boundary of the West Coast North Island Marine Mammal Sanctuary is plotted in magenta.

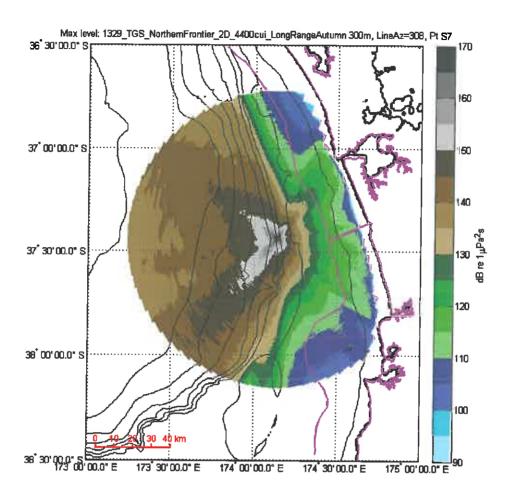


Figure 24. Geographical distribution of modelled sound exposure level for a source on the 300m depth contour at S6 to a maximum range of 80km - autumn sound speed profile. (Maximum level at any depth.) Survey line azimuth is 308°T. The boundary of the West Coast North Island Marine Mammal Sanctuary is plotted in magenta.

These effects are illustrated in Figure 25 and Figure 26, which show vertical cross-sections through the sound field produced by a source at S2 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. Shorwards from the source the sound field is fairly uniform vertically, whereas offshore the downwardly refracting sound speed profile results in the higher sound levels being found in the lower half of the water column.

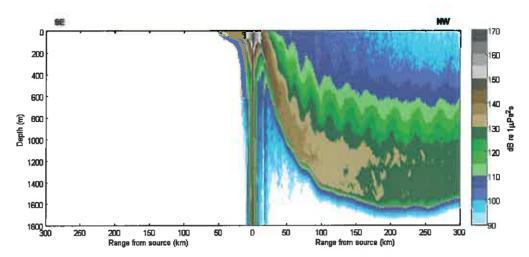


Figure 25. Vertical cross-section through the sound field in thein-line direction (130°T - 310°T), centred on S2, the magenta line outlines seabed.

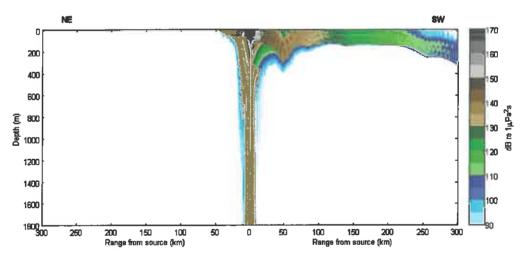


Figure 26. Vertical cross-section through the sound field in the cross-line direction (40°T - 220°T), centred on S2, the magenta line outlines seabed.

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 airgun array 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.

The short range modelling predicted that the maximum sound exposure levels from the Aquila 4400 cubic inch array and the Nucleus 4140 cubic inch array would be below the threshold of 186 dB re 1 μ Pa².s at 200 m and below 171 dB re 1 μ Pa².s at 1 km. Levels produced by the 4140 cubic inch array are predicted to be between 1 and 3.5 dB lower than those produced by the 4400 cubic inch array depending on range.

Modelling also predicted that operations in the shallowest waters (70 m) present in the Northwest Frontier survey area will produce maximum sound exposure levels of 188.2 dB re 1 μ Pa².s at 200 m and 176.3 dB re1 μ Pa².s at 1 km. These levels were predicted to drop below thresholds of 186 dB re 1 μ Pa².s and 171 dB re 1 μ Pa².s at ranges of 270 m and 2.24 km respectively. Maximum sound exposure levels were predicted to drop below 186 dB re 1 μ Pa².s at 200m and below171 dB re 1 μ Pa².s at 1km when the source operates in water depths greater than 300 m.

The long range modelling results were highly directional due to the combined effects of airgun array directionality and bathymetry. Levels showed moderate attenuation inshore of the source and slow attenuation offshore. Maximum levels at the outer boundary of the West Coast North Island Marine Mammal Sanctuary due to a source in 97m water depth, 20 km from the boundary, were predicted to be 145 dB re $1 \mu Pa^2$.s.

Restricting the source to deeper water markedly reduced the inshore sound levels. A source in 300m of water, 26 km from the outer marine mammal sanctuary boundary was predicted to produce maximum levels of 127 dB re 1 μ Pa².s at the boundary.

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APPENDIX 6

NWF 2D 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	manus LOW Co.
Changes in seabird behaviour.	4	4	16	lev
Introduction of marine pests or invasive species	3	4	12	1.0%
Interaction with marine mammals	3	3	9	Mediam
Changes in abundance or behaviour of fish	3	3	9	Mearum
Avoidance and startle responses in marine mammals and other marine megafauna	3	3	9	Musicum
Disruption to feeding activities	3	3	9	Modum
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	
Physiological effects on fish	3	4	12	Tto
Physiological effects on larvae	3	4	12	DOW
Physiological effects on benthos	3	4	12	LHW
Physiological effects on deepwater corals	4	4	16	Cow
Physiological effects on cephalopods	3	4	12	lime .
Generation of sewage and greywater	4	3	12	112
Generation of galley waste and garbage	4	3	12	(Cition
Generation of oily waters	4	4	16	Litter
Atmospheric emissions	4	4	16	
Cumulative effects from seismic surveys	4	4	16	# 1
Unplanned Activities				
Streamer break or loss	4	4	16	Cha
uel or oil spilis	4	4	16	LOw
Vessel collision or sinking	4	3	12	179.0
Average Values	35	3.6	13	
Overall Significance Risk Ranking of NWF 2D MSS Programme			13	Lov

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