Environmental Offshore Services Limited

New Zealand Oil & Gas 54857 Limited

Waru 2D Marine Seismic Survey

Marine Mammal Impact Assessment

25 March 2014

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Table of Contents

List of Figures

List of Tables

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 Ltd	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

NABIS	National Aquatic Biodiversity Information System
NIWA	National Institute of Water and Atmospheric Research
Nm	Nautical Mile
NZ	New Zealand
NZOG	New Zealand Oil & Gas 54857 Limited
NZP&M	New Zealand Petroleum & Minerals
OMV	OMV New Zealand Limited
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
SLIMPA	Sugar Loaf Island Marine Protected Area
SOPEP	Shipboard Oil Pollution Emergency Plan
SRD	Self-Recovery Devices
STLM	Sound Transmission Loss Modelling
TACC	Total Allowable Commercial Catch
TRC	Taranaki Regional Council
WAUC	West Auckland Current
WC	Westland Current

1 Introduction

1.1 Background

Environmental Offshore Services Limited (EOS Ltd) have been engaged by New Zealand Oil & Gas 54867 Limited (NZOG) to prepare a Marine Mammal Impact Assessment (MMIA) for an approximate 435 line km 2D Marine Seismic Survey (MSS) in the South Taranaki Bight, scheduled to commence in March 2014. The Waru 2D Survey Area will be largely located within Petroleum Exploration Permit (PEP) 54857 with a proposed 35 km tie line to the Ruru-1 well within PEP 381203.

The Waru 2D Survey Area will be bound by the Waru Operational Area; allowing for the operation of line turns, acoustic source testing and soft start initiation (Figure 1). It is anticipated that the Waru 2D MSS will take approximately 5 days to complete, depending on weather constraints and marine mammal encounters. The actual commencement date of the Waru 2D MSS is dependent on the seismic vessel *Aquila Explorer* completing prior MSS's, however, with the current schedule is anticipated to commence approximately 26th-27th March 2014, but this could be delayed if any delays occur in the *Aquila Explorer's* prior commitments.

Under Section 23 of the Crown Minerals Act 1991, the purpose of a PEP is to identify petroleum deposits and evaluate the feasibility of mining any discoveries that are made, and is exclusive to the permit holder. PEP 54857 allows NZOG to undertake geological or geophysical surveying, exploration and appraisal drilling and testing of petroleum discoveries, however this MMIA is only in relation to the acquisition of a 2D MSS.

The Waru 2D MSS will acquire approximately 435 lineal km of 2D seismic data to provide a general understanding of the geological structure within PEP 54857 and to identify more prospective areas for further investigation utilising a 3D MSS to enhance structural interpretation and allow these areas to be more comprehensively examined. Further details of 2D and 3D MSS's are provided in Section 3.1.

The Exclusive Economic Zone (EEZ) and Continental Shelf (Environmental Effects – Permitted Activities) Act (EEZ Act) manages the previously unregulated potential for adverse environmental effects of activities in the EEZ and continental shelf. MSS are classified as permitted activities within the EEZ Act as long as the operator undertaking the MSS complies with the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations' (Code of Conduct) (DOC, 2013).

Approximately half of the Waru 2D Survey Area is within the EEZ while the inshore portion is within the Coastal Marine Area (CMA) administered by Taranaki Regional Council. The Code of Conduct is not mandatory within the CMA, however NZOG will adhere to the Code of Conduct requirements throughout the entire Waru Operational Area. Further details of the Code of Conduct are provided in Section 2.

The Waru 2D MMIA has been prepared in accordance with the Code of Conduct (Appendix 1: Marine Mammal Impact Assessment) to assess the potential environmental effects from the Waru 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).

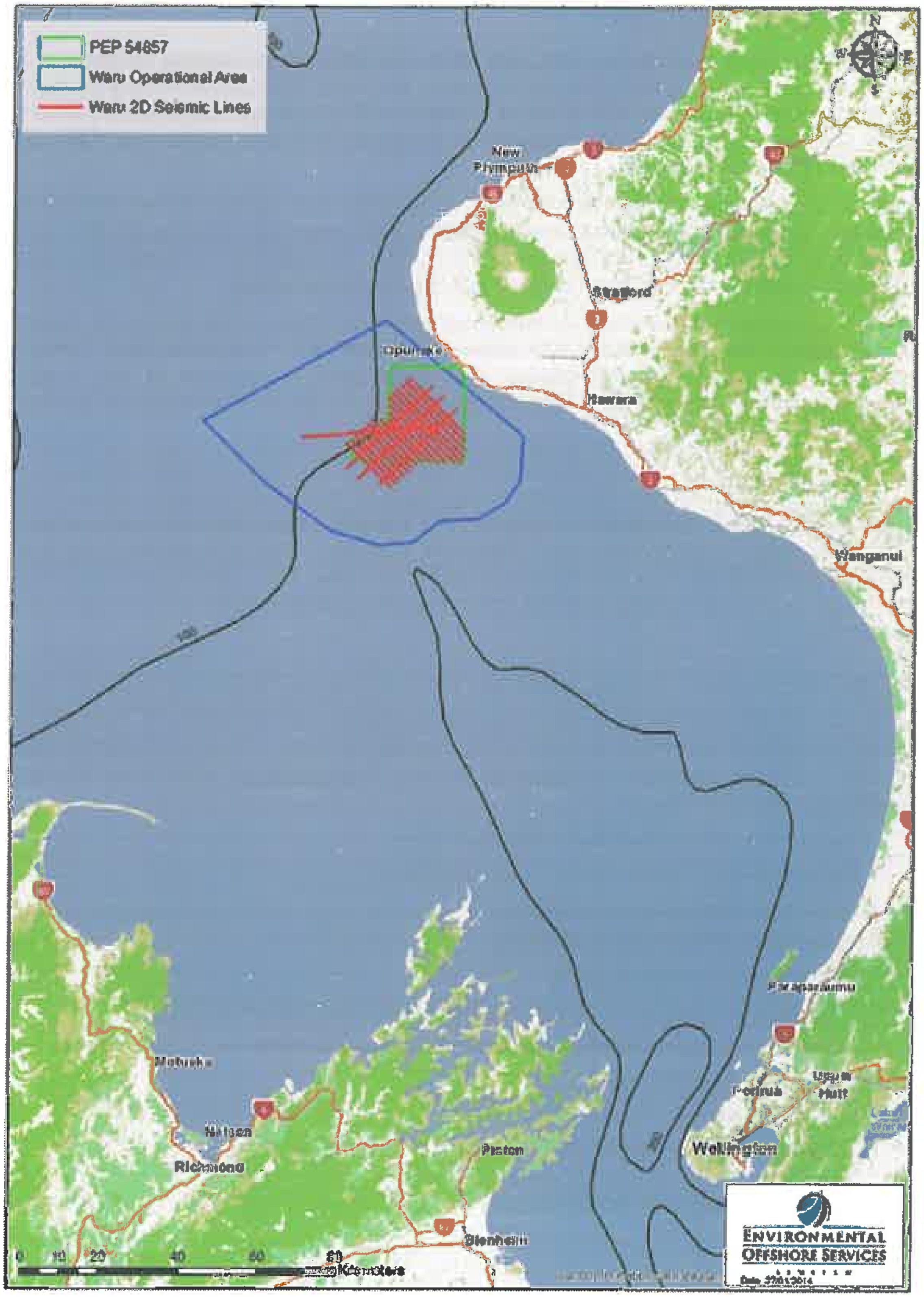

Figure 1: Location Map of the Waru 2D MSS and Operational Area

1.2 General Approach

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

Within the Code of Conduct, the Waru 2D MSS is classified as a 'Level 1 Survey' and NZOG will comply with these requirements and mitigation measures while carrying out the MSS. The requirements of a Level 1 survey under the Code of Conduct and mitigation measures that NZOG will implement is outlined in Section 2.2.1 and Section 5.3.1.

During the preparation of the Waru 2D MMIA an extensive review of literature and existing data was used from both national and international sources. This information forms a considerable amount of the background information and descriptions of the existing environments surrounding the Waru Operational Area. A full list of references can be found in Section 8.

1.3 Consultation

NZOG has undertaken consultation throughout the Taranaki region over the last few years with iwi, key local stakeholders and interested parties. This consultation has been undertaken regarding the Kokako and Karoro 3D MSS within PEP 53473 and PEP 52593 respectively, as well as visiting local iwi before NZOG submitted bids on the PEP's they currently hold.

For the purpose of the Waru 2D MSS key interested parties and stakeholders were identified in relation to the seismic activities within the Waru Operational Area and were consulted either in person, through an information sheet or contacted over the phone to describe the proposed Waru MSS operations and the Waru Operational Area. A copy of the information sheet sent out for the consultation process is attached in Appendix 1. The groups that were consulted with are listed below:

- Department of Conservation – National Office;
- Department of Conservation – Taranaki Office;
- Environmental Protection Authority;
- New Zealand Petroleum & Minerals;
- Ministry for Primary Industries;
- Petroleum Exploration & Production Associated New Zealand (PEPANZ);
- Southern Inshore Fisheries Management Company Limited;
- Challenger Finfisheries;
- Egmont Seafoods;
- Taranaki Commercial Fishing Federation;
- Sealord;
- Maruha NZ Ltd;
- Independent Fisheries;
- Talley's Group;
- Sanford Limited;
- Southern Inshore Fisheries Management Company Limited;
- Challenger Finfisheries;
- Taranaki Recreational Fishing Council;

- New Plymouth Sportfishing & Underwater Club;
- Cape Egmont Boat Club;
- Opunake Boat Club;
- Fisheries Inshore New Zealand;
- Port Taranaki;
- Port Taranaki Harbourmaster;
- Taranaki Regional Council;
- South Taranaki District Council;
- Maritime New Zealand;
- Venture Taranaki;
- Land Information New Zealand;
- Taranaki Iwi Trust;
- Nga Hapu o Nga Ruahine Iwi Inc;
- Te Runanga o Ngati Ruanui;
- Ngati Tamaahuroa me Titahi;
- Ngati Haua hapu;
- Ngati Haumia;
- University of Auckland;
- University of Otago; and
- Leigh Torres - National Institute of Water & Atmosphere (NIWA).

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

1.4 Research

Throughout the world where MSS's 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 (DOC, 2013), while not duplicating international efforts.

NZOG have contributed to a desktop study that is nearing completion on the effects of seismic operations on NZ fur seals which is being funded by the petroleum industry. Over the last few years Marine Mammal Observers (MMO) have recorded the behaviour of NZ fur seals when they are in close proximity to a seismic vessel, streamers or the acoustic source. This information has formed part of the data set for the desktop study.

The Code of Conduct states that within 60 days following the completion of the Waru 2D MSS, a final MMO report is to be submitted to DOC providing all 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 be included in the DOC marine mammal sighting database and can be used for research purposes by DOC, Universities or other institutions to keep developing the knowledge of marine mammals in regards to distribution and behaviour around an operating seismic vessel.

As an additional mitigation measure while conducting the Waru 2D MSS; NZOG will have Massey University perform a necropsy on any marine mammals found dead inshore of the Waru Operational Area, along the Taranaki and Wanganui coastline during the Waru 2D MSS and for a period two weeks after the Waru 2D MSS is completed. If a necropsy is performed it will be to assess if the cause of death was from any auditory pressure related injuries. The two week time frame after the MSS is to demonstrate that death was not caused by auditory pressure related injuries, which, in the unlikely event they occurred, may be some time after exposure to the acoustic source. DOC will be responsible for all aspects of undertaking the necropsy and coordination with pathologists at Massey University; however NZOG will cover the associated costs.

NIWA conducted a research voyage in the South Taranaki Bight in late January 2014 as part of a current research project on blue whales in the South Taranaki Bight. Sampling methodology involved photo-id, tissue sampling for genetics and stable isotopes, conductivity, temperature and depth (CTD) casts and plankton tows. It is hoped that the data collected will help address population and ecological gaps in the knowledge on blue whales. As part of the Waru 2D MSS, NZOG will provide any sighting information of blue whales to NIWA to help build on NIWA's research.

2 Legislative Framework

The NZ Governments 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 Waru 2D MSS, NZOG are required to comply with the EEZ Act – Permitted Activities and the Code of Conduct.

2.1 Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act

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

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

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

- **Permitted** – the activity can be undertaken provided the operator meets the conditions specified within the regulations. Marine seismic surveys are a permitted activity as long as the operator complies with the Code of Conduct;
- **Non-notified discretionary** – activities can be undertaken if applicants obtain a marine consent from the 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 Environmental Protection Authority (EPA) must assess the marine consent application. (Note: this classification is not yet in effect, it will come into effect when activities are first classified under it);
- **Discretionary** – activities 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 in 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.

2.2 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations

The Code of Conduct has been developed by DOC in consultation with a broad range of stakeholders involved with marine seismic survey operations in NZ and on 29 November 2013 replaced the 2012 Code of Conduct. The 2012 Code of Conduct was initially developed as a voluntary regime to manage the potential effects of seismic survey activities, of which the petroleum industry adopted while carrying out MSS operations in NZ waters. 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. However, when the EEZ Act came into effect on 28 June 2013, seismic surveys were classified as permitted activities (Section 2.1), requiring operators undertaking a MSS in the EEZ or Continental Shelf to operate in compliance with the Code of Conduct. This resulted in a review of the 2012 Code of Conduct to take into account a few operational difficulties that were found through the first seismic season operating with the 2012 Code of Conduct and to make the Code of Conduct enforceable from a regulatory perspective.

The update to the 2013 Code of Conduct incorporated a number of amendments; including a reduced period of time that the NZ fur seal has to be beyond the 200 mitigation zone before the pre-start observations can commence, operational procedures to implement if the PAM system malfunctions and a slight change to pre-start observations. The full mitigation requirements within the updated 2013 Code of Conduct are provided in Section 2.2.1.

The Waru 2D MSS is classified as a Level 1 survey within the Code of Conduct; where the acoustic source has a total combined operational capacity that exceeds 427 cubic inches (in^3). Most MSS for oil and gas exploration activities are classified as Level 1, which feature the most stringent requirements for marine mammal protection and is the main focus of the Code of Conduct.

Any operator undertaking a MSS (except those classified as Level 3) has to provide notification to the Director-General of DOC at the earliest opportunity but not less than three months prior to commencement.

The Code of Conduct requires a MMIA to be developed and submitted to the Director-General to ensure that all potential environmental effects and sensitivities have been identified and measures to reduce those potential environmental effects are in place.

When MSS are conducted in Areas of Ecological Importance (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. The Waru Operational Area is located within an AEI; the additional measures that NZOG will implement, following discussions with DOC are identified in Section 5.3.2.

As well as visual MMO's onboard the Survey Vessel, Passive Acoustic Monitoring (PAM) is required as a mitigation measure under a Level 1 MSS. A Vanishing Point (VP) PAM system will be utilised for the Waru 2D MSS, and further information relating to the PAM system was provided by the Sea Mammal Research Unit, St Andrews University following requests for further clarification by DOC relating to the PAM specifications.

It was stated that 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 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 Waru 2D MSS also confirmed that the PAM system planned to be used is suitable for detection of NZ endemic and vagrant marine mammal species.

Technical details of the PAM system to be used in the Waru 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 the MMO and PAM system provider Blue Planet Marine and is attached in Appendix 4.

In November 2013, the Ministers of Conservation and Primary Industries announced a number of decisions relating to measures to mitigate human-related threats to Maui's dolphins under the Threat Management Plan. Within the Threat Management Plan review process it was highlighted that oil and gas exploration, vessel strikes, and disease are the highest non-fishing related threats to Maui's dolphins. In relation to MSS's it is proposed to make the Code of Conduct a mandatory standard by reference under section 28 of the Marine Mammal Protection Act. This would apply in Territorial waters, EEZ and within the Marine Mammal Sanctuaries (i.e. in all NZ waters).

2.2.1 Level 1 Marine Seismic Survey

For compliance with the Code of Conduct, NZOG must submit a MMIA to the Director-General at least one month prior to commencement of the Waru 2D MSS. The observer and operational requirements which NZOG will adhere to for the Level 1 MSS are listed in the following sections.

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

The STLM is discussed in more detail in Section 5.1.2.1 however the results are briefly summarised here as the mitigation zones for Species of Concern (without calve) have been increased following the STLM so need to be incorporated into the operational procedures for the Waru 2D MSS within this section. STLM showed that compliance was achieved with the Code of Conduct where 100% of SEL's greater than 186 dB re 1µPa^2.s were within 200 m of the acoustic source, however 95% of SEL's were below 171 dB re 1µPa^2.s at 1.1 km and

100% were below at 1.5 km. Therefore, due to SEL's of 171 dB re 1μPa^2.s being greater than 1 km from the acoustic source, the mitigation zone for Species of Concern will be increased from 1.0 km to 1.5 km for the Waru 2D MSS throughout the entire Waru Operational Area. The increased mitigation zone has been incorporated throughout this MMIA for the relevant mitigation measures and compliance with the Code of Conduct.

The mitigation zone for Species of Concern with calve present in the Code of Conduct will remain at 1.5 km, as the STLM showed this distance is compliant with the behaviour criteria requirements.

2.2.1.1 Observer Requirements

To undertake the Waru 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 Waru 2D MSS is strictly for the detection and data collection of marine mammal sightings, and instructing crew on the Code of Conduct and 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 Waru 2D MSS the MMO's onboard the *Aquila Explorer* consider that there are higher numbers of marine mammals encountered than what is believed through the formation of 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 NZOG, who shall then advise the MMO/PAM team of the correct approach.

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 MMO's 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.

2.2.1.2 Operational and Reporting Requirements

Both visual MMO's and PAM operators are required to record and report all marine mammal sightings during MSS's conducted in adherence to the Code of Conduct.

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.

While PAM operator requirements include:

- Give 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 for when required to attend to PAM equipment;
- Use appropriate sample analysis and filtering techniques;
- Record and report all cetacean detections, including, if discernable, 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.

2.2.1.3 Pre-start Observations

Normal Requirements

The Waru 2D MSS acoustic source can only be activated if it is within the Waru Operational Area (Figure 1) and no marine mammals have been observed or detected in the relevant mitigation zones (Section 2.2.1.4).

During daylight hours the Waru 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 Waru 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.

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 (2,360 in^3) is not to be exceeded during the soft start period.

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

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

- MMO's 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 MMO's have conducted visual monitoring in the two hours immediately preceding proposed MSS operations;
    - No Species of Concern (DOC, 2013 – Schedule 2) have been sighted during visual monitoring or detected by PAM in the relevant mitigation zones in the two hours immediately preceding proposed MSS operations;
    - No fur seals have been sighted during visual monitoring in the relevant mitigation zone in the 10 minutes immediately preceding proposed MSS operations; and
    - No other marine mammals have been sighted during visual monitoring or detected on the PAM system in the relevant mitigation zones in the 30 minutes immediately preceding proposed MSS operations.

2.2.1.4 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 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 1.5 km

If during pre-start observations or while the acoustic source is activated, a qualified observer detects a Species of Concern 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 Species of Concern 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 a Species of Concern within 1.5 km of the source, and the mitigation zone remains clear.

Other Marine Mammals within a mitigation zone of 200 m

If during pre-start observations prior to initiation of the Waru 2D MSS acoustic source soft start procedures, a qualified observer detects a marine mammal within 200 m of the source; start-up will be delayed until:

- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m from the source; or
- Despite continuous observation, 10 minutes has 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.

2.3 Areas of Ecological Importance

MSS operations within an 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 feeding or migrating, calving, resting, feeding or migrating, or where risks are particularly evident such as in confined waters. There is the potential that during the Waru 2D MSS blue whales may be present within the South

Taranaki Bight if weather and oceanographic conditions permit upwelling to arise from the Kahurangi Shoals; resulting in plankton blooms that the blue whales feed on. The Waru Operational Area is located within an AEI, as shown in Figure 19.

NZOG has a work commitment to the NZ Government that they have to acquire and process a minimum of 400 km's of 2D seismic data in order to meet the requirements stipulated in PEP 54857. The timing of the Waru 2D MSS is scheduled to coincide with vessel availability and the settled summer weather period, allowing the Waru 2D MSS to be undertaken in the shortest possible timeframe, essentially reducing any excess noise being emitted to the marine environment for a longer period due to weather delays. There is a considerable expense to mobilise a specialised seismic vessel to NZ; therefore NZOG have contracted the *Aquila Explorer* to undertake the Waru 2D MSS while the specialised 2D seismic vessel is already in NZ waters rather than having to mobilise another vessel to NZ. It is also noted that information gathered from the MMO reports following the completion of the MSS undertaken to date in the South Taranaki Bight has provided a greater awareness and knowledge of marine mammal distribution within this area.

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, namely 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 in which the MMS was gazetted to protect.

The closest MMS to the Waru Operational Area is the West Coast North Island MMS which was gazetted in 2008 and stretches from Maunganui Bluff to Oakura Beach, Taranaki in the south (Figure 17) and extending out to 12 Nm has an approximate area of 1,200,086 hectares and covers 2,164 km of coastline. As stated above there are restrictions in place for seismic surveys within MMS's, however, they can still be undertaken as long as they are undertaken in accordance with the Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008. The West Coast North Island MMS was gazetted to protect Maui's and Hector's dolphins.

In 2013 the Minister of Conservation varied the West Coast North Island 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 km^2 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).

The Waru Operational Area is located 50 km southeast of the West Coast North Island MMS southern boundary.

3 Project Description

3.1 Marine Seismic Surveys

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

The details of a specific MSS can vary enormously, however there are two principle categories of MSS's, 2D and 3D and the complexity between the two varies greatly. A 2D MSS can be described as a fairly basic survey method which involves a single acoustic source and a single streamer towed behind the seismic vessel (Figure 2). However, although the MSS is simplistic in its underlying assumptions, it has been and still is today used very effectively to discover oil and gas reservoirs. Using this method the reflections from the subsurface are assumed to lie directly below the sail line that the seismic vessel traverses. Sail lines are generally acquired several kilometres apart, on a broad grid over a large area. This methodology is generally used for frontier exploration areas to produce a general understanding of the regional geological structure and to identify more prospective areas which can be comprehensively examined through a 3D MSS.

Whereas, a 3D MSS is a more complex method and involves a greater investment and much more sophisticated equipment compared to a 2D MSS. The purpose of a 3D MSS is to focus on a specific area over known geological targets considered likely to contain hydrocarbons, generally discovered by previous 2D MSS. Extensive planning is undertaken to ensure the survey area is precisely defined and the direction of the survey lines are calculated to ensure the best results are obtained of the underlying geology in the received seismic images for interpretation. 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 2).

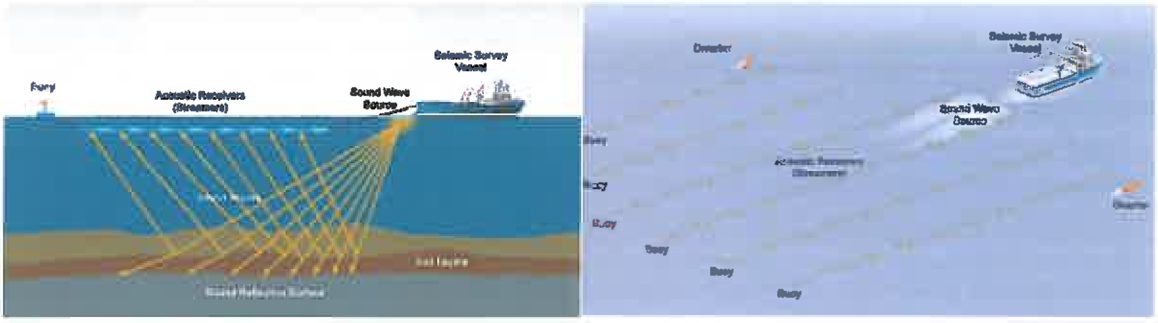

Figure 2: Schematic of a 2D MSS (left) and 3D MSS (right)

The acoustic source comprises of two high pressure chambers; an upper control chamber and a discharge chamber (Figure 3). High pressure air (~2,000 psi) from compressors onboard the seismic vessel is continuously fed to the acoustic source 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 3).

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 fired again. The compressors are capable of recharging rapidly and continuously, enabling the acoustic source to be fired every 8 – 10 seconds during seismic acquisition.

The acoustic source arrays are designed so that they direct most of the sound energy vertically downwards (Figure 3) 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 ~200 – 220 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, while in adverse weather conditions, the background noise increases to 90 dB (Bendell, 2011).

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

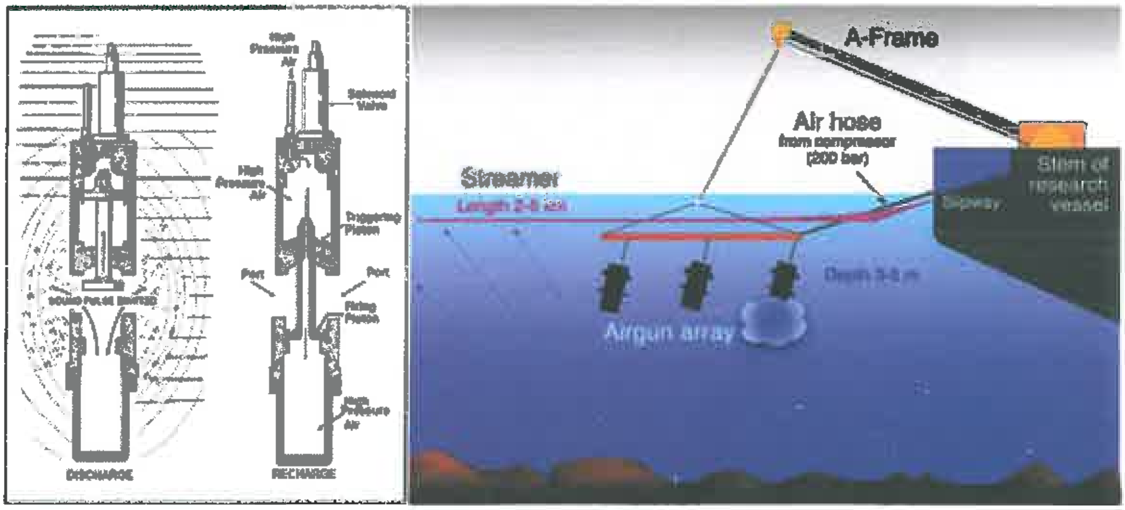

Figure 3: Schematic cross section of a typical acoustic source and a sub-surface array

For a 2D MSS one streamer is towed behind the seismic vessel, whereas for a 3D MSS up to 10 streamers can be towed, and these can be influenced by wind, tides and currents, causing feathering, or the streamers being towed in an arc offset from the nominal sail line. When the acoustic source is activated the streamers detect the very low level of reflection energy from the geological structures below the seabed using pressure sensitive devices called hydrophones. Hydrophones convert the reflected pressure signals into electrical energy that is digitised and transmitted along the streamer to the recording system onboard the seismic vessel.

Each streamer is divided into sections, 50 – 100 m in length to allow for modular replacement of damaged components. Solid streamers are more often used now, and are constructed of extruded foam to make them neutrally buoyant. The generation of solid streamers has many advantages over the older fluid filled streamers, where they are: more robust and resistant to damage (i.e. shark bites); are less sensitive to weather and wave noise (provides higher quality seismic images); require less frequent repairs; and the modern streamers are steerable allowing greater control of the streamers, resulting in less infill lines, reducing the cumulative sound energy introduced into the marine environment.

Towing a streamer underwater removes it from the surface weather and noise which limits the usability of the recorded data and other technical requirements. The deeper the tow depth, the quieter the streamer in regards to weather and surface noise, but this also results in a narrower bandwidth of the data. Typically the range of operating depths varies from 4 – 5 m for shallow high resolution surveys in relatively good weather to 8 – 10 m for deeper penetration and lower frequency targets in more open waters.

At the end 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 (Figure 4). During the Waru 2D MSS, the *Aquila Explorer* will be travelling at 4.5 kts so the streamer tail buoy will be travelling approximately 50 minutes behind the vessel.

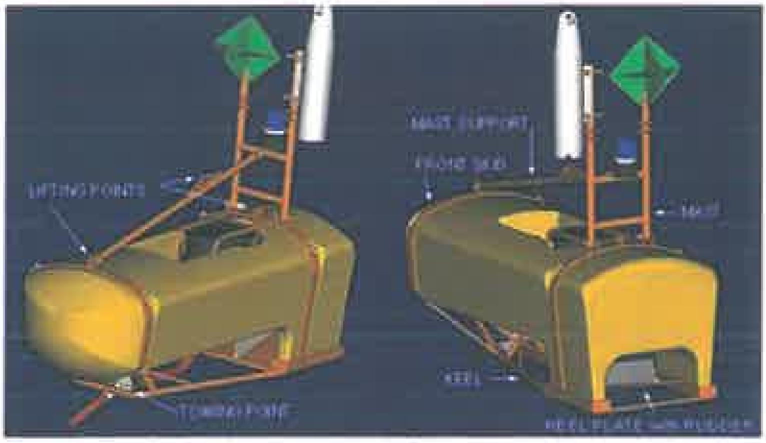

Figure 4: Example of a tail buoy with light and radar reflector

3.2 Waru 2D Marine Seismic Survey

The Waru 2D MSS will use the seismic vessel *Aquila Explorer* and will tow one solid streamer, 8 km in length. NZOG will utilise a 2,360 in^3 acoustic source comprising of four sub-arrays located at a depth of 5 m below the sea surface and > 50 m behind the *Aquila Explorer*. This acoustic source has been selected to ensure the source volume enables the survey to be run effectively in regards to data acquisition, but to also 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 Waru 2D MSS outlined within this MMIA. The STLM is further discussed in Section 5.1.2.1 and is attached in Appendix 5.

The acoustic source will have an operating pressure of 2,000 psi and fired at a shotpoint interval of 18.75 m apart, where for a typical boat speed of 4.2 – 4.5 knots (kts), relates to a shot being fired every 8 – 8.5 seconds.

NZOG are planning to acquire the Waru 2D MSS in mid-March 2014 depending on the completion of prior surveys and is scheduled to take approximately 5 days. MSS operations will be conducted 24 hours per day, subject to suitable weather conditions and marine mammal encounters within the mitigation zones. The technical specifications of the *Aquila Explorer* are provided in

Table 1. One support vessel, the *Amaltal Mariner* (Figure 6) will be contracted for the duration of the MSS and will be in close proximity to the *Aquila Explorer* at all times.

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

- **Mobilisation of the *Aquila Explorer* to the Waru Operational Area:** After the *Aquila Explorer* has completed its previous MSS, it is likely that the *Aquila Explorer* will mobilise directly to the Waru Operational Area. The *Amaltal Mariner* will accompany the *Aquila Explorer* at all times during the passage to the Waru Operational Area. During transit to the Waru 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 5.3.2.3);
- **Deployment of Streamers:** 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 the pre-start observations as required under the Code of Conduct when arriving at a new location (Section 2.2.1.2). Once these procedures have been followed and adhered to, a soft start can begin for commencement of the Waru 2D MSS;
- **Data Acquisition:** The *Aquila Explorer* will follow predetermined survey lines (Figure 1) which have been calculated to get the best images and provide greater interpretation of the underlying geology. The four MMO's on board will monitor for marine mammals throughout the 24 hour period for the duration of the MSS to ensure compliance with a Level 1 survey under the Code of Conduct. There will be no continuous line acquisition (acquiring seismic data through the line turns) for the Waru 2D MSS, so the acoustic source will be stopped at the end of each survey line and the MMO's will commence pre-start observations prior to each survey line; and
- **Demobilisation:** Once the *Aquila Explorer* has completed the Waru 2D MSS, the acoustic source will be stopped and the seismic array will be left deployed for mobilisation to the OMV Mohua 2D Operational Area, approximately 50 km offshore.

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 5: Seismic Survey Vessel – *Aquila Explorer*

Figure 6: Seismic Support Vessel – *Amaltal Mariner*

Table 1: *Aquila Explorer* Technical Specifications

Seismic Survey Vessel – General Specifications	
Vessel Name	M/V *Aquila Explorer*
Vessel Owner	Aquila Explorer Inc.
Engine Details	2 x MAK 6M AK 1770KW
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 2: Waru 2D Seismic Specifications

Parameter	Specifications
Total array volume	1 x 2,360 in^3
Acoustic source	Bolt 1900 LLXT
Number of arrays	1
Number of sub-arrays	2
Source length	14 m
Source width	10 m
Nominal operating pressure	2,000 psi
Tow depth	8 m (+/- 1m)
Distance from the stern	> 50 m
Number of streamers	1
Streamer length	8 km
Streamer manufacturer/model	Sercel Seal
Towing depth	~12 m (+/- 1m)

3.3 Navigational Safety

During the Waru 2D MSS, the *Aquila Explorer* will be towing one streamer, 8 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 and the International Regulations for the Prevention of Collisions at Sea (COLREGS) 1972 which is implemented in NZ under the Maritime Transport Act regime. A Notice to Mariners will be issued and will be broadcast daily on maritime radio advising of the Waru 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 day and night.

3.4 Analysis of Alternatives

Most MSS's conducted throughout the world these days use acoustic sources, as they generate low frequency sources which can image the underlying geology several kilometres below the seafloor. Each component of the Waru 2D MSS has the requirement to not only gather the best information of the underlying geology and hydrocarbon potential within the Waru Survey Area and tie in to known geological structures but to also reduce any adverse effects on the marine environment to the fullest extent practicable.

NZOG will use 'Bolt 1900 LLXT' acoustic sources for the Waru 2D MSS, with the acoustic source consisting of four sub arrays. The energy source and acoustic 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 Waru 2D MSS design, NZOG had the selection of 4,230 in^3 or 2,360 in^3 acoustic sources that are onboard the *Aquila Explorer* to acquire the Waru 2D MSS. In keeping with the nature of the Code of Conduct, NZOG selected the 2,360 to reduce the amount of noise emitted to the marine environment.

The acquisition period for the Waru 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.

The main migration period of humpback whales to the South Pacific Breeding grounds is through June-July, although it is known to extend either side of this. The humpback whales make their way north through the Cook Strait and will do so after the Waru 2D MSS is complete.

Southern right whales are known to make migrations down to the Southern Ocean to feed during the summer months, while their northern migrations appears to pass through the Taranaki region between May-October. Southern right whales also appear to have a coastal habitat use pattern, especially when they are on their breeding or calving grounds (Torres, 2012). Most sightings around the Taranaki have also being coastal, so given the timing of the Waru 2D MSS during the summer period, it is believed that the southern right whales are therefore not likely to be impacted during the Waru 2D MSS.

Blue whales have been observed in the South Taranaki Bight during the summer period which appears to be an important feeding ground due to the potential for large aggregations of krill to form following upwelling from the Kahurangi shoals. However blue whales have also being observed during winter months feeding on the krill, indicating upwellings that aggregate the krill and subsequently the blue whales are related to wind and currents, rather than simply the time of year. Weather patterns appear to play an important factor in the presence of blue whales in the South Taranaki Bight. If upwellings result in large aggregations of krill being present, blue whales are often observed, however if no upwelling occurs or rough seas break up any aggregations of krill, the blue whales will continue searching for food, due to their high daily food requirements. A NIWA research voyage the end of January 2014 found a large number of blue whales present in the South Taranaki Bight, whereas at the start of January 2014 OMV undertook a MSS which did not result in any positively identified blue whales during a 12 day survey period. As a result the commencement of the Waru 2D MSS during March will not coincide with any specific feeding season of the blue whales given they have been observed in feeding congregations throughout the year, and any effects will be reduced through compliance to the Code of Conduct and the short duration of the Waru 2D MSS.

NZOG have work programme commitments, agreed with NZP&M to assess the petroleum potential of PEP 54857; of which a minimum of 400 km's of 2D seismic data acquisition is required. As a result there is no 'do nothing' option in regards to a 2D MSS.

4 Environmental Description

4.1 Physical Environment

4.1.1 Meteorology

Anticyclones are a major feature of the weather in the Australian-NZ region and migrate eastwards every six to seven days across NZ, where the centres generally pass across the North Island; northerly paths are followed during spring and southerly paths during autumn and winter.

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

The South Taranaki Bight is subject to high winds and seas due to being directly exposed to weather systems that approach from the Tasman Sea. Within this area prevailing winds and swells approach from the west to southwest, and although there are few climatic extremes the weather can be very changeable. During winter, the weather conditions are more unsettled and cooler compared to summer months.

Weather conditions from New Plymouth have been used as indicative for the Waru Operational Area, where summer daytime temperatures can range from 19°C to 24°C, whereas the relatively mild unsettled winterers have temperatures from 10°C to 14°C (NIWA, 2014). The mean monthly weather parameters at New Plymouth is shown in Table 3.

Table 3: 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	36	31	47	58	31	37

(Source: Weather 2, 2014)

4.1.2 Wind Climate

Within the South Taranaki Bight from previous modelling reports undertaken at various locations, it has been shown that there are two dominant wind directions in this area of coastline; from the west and southeast. West-southwesterly winds are most prevalent from October through to February, while typically the strongest winds are from the southeast. It is generally regarded in the offshore Taranaki area that September is the windiest month, while January is the calmest.

4.1.3 Wave Climate

The Waru Operational Area has a high energy wave environment present due to its location in relation to the Tasman Sea in the west and the Greater Cook Strait to the southeast. The Southern Ocean can generate long period swells; often enhanced by the predominant west to southwest winds. Waves from the south are often fetch-limited due to the strong southeast winds, resulting in steep and energetic seas.

4.1.4 Bathymetry

Each major land mass is surrounded by a flat, gently sloping zone known as the Continental Shelf which extends from the coast out to a water depth of approximately 100 – 200 m. Beyond the Continental Shelf, the slope 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 Continental Slope, the seaward gradient flattens out into the Ocean Basin which is a wide undulating but relatively flat zone lying at the 4,000 to 5,000 m and covers most of the central parts of the major oceans (Te Ara, 2014a).

The surface of the Continental Shelf is predominantly flat although diversified by local banks and reefs, whereas the slope is more irregular, being cut in many areas by the 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 NZ coastline's Continental Shelf varies in width from one area to another; where the narrowest parts are found off the east coast of NZ between Kaikoura and Cape Kidnappers with a width that varies between 1 – 15 Nm. Whereas other parts of NZ have a more extensive Continental Shelf that can be up to 40 Nm wide, with the western Cook Strait and south of Stewart Island having a Continental Shelf which extends to over 100 Nm (Te Ara, 2014a).

The gradient of the Continental Slope varies a lot around NZ, although there is a broad correlation between steepness of the Continental Slope and the narrowness of the Continental Shelf.

The Taranaki Continental Shelf has a 150 km wide opening to the Tasman Sea, occupying 30,000 km^2 and slopes gently towards the west with an overall gradient of $<0.1°$ and locally less than 0.5° (Nodder, 1995).

The bathymetry through the Waru Operational Area is sloping to the west-southwest on a sloping gradient towards the shelf break with a water depth from the inside boundary of approximately 50 m to ~ 100 m on the offshore boundary (Figure 7).

Although the bathymetry throughout and surrounding the Waru Operational Area has a low overall gradient, there are numerous undulations, which give rise to a complex bathymetry. The seabed complexity throughout this South Taranaki Bight region is likely to be due to the re-working of Late Quaternary sediments (sand and gravel) by littoral and aeolian processes.

Figure 7: Bathymetry of the Waru Operational Area

4.1.4.1 Current Regime

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 NZ being exposed to the southern branch of the South Pacific subtropical gyre, driven by the southeast trade winds to the north and the Roaring Forties westerly winds to the south (Gorman *et al.*, 2005). The anti-clockwise circulation of the gyre is initiated by the winds but is then further modified by the spin of the earth (Coriolis Effect).

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

The West Auckland Current (WAUC) flows south along the west coast of the North Island and is met by the north-flowing currents in the North Taranaki Bight (Figure 8). Along the west coast of the South Island the Westland Current (WC) flows in a northerly direction before it merges with the D'Urville Current (DC) and moves into the South Taranaki Bight. The DC flows into the Cook Strait from the northwest where it mixes with water from the Southland Current (SC) and East Cape Currents (ECC) (Figure 8).

Within the South Taranaki Bight the dominant ocean currents are caused by the local and regional wind stresses on the ocean's surface in combination with tidal flows.

Figure 8: Ocean Circulation around the New Zealand coastline
(Source: http://www.teara.govt.nz/en/map/5912/ocean-currents-around-new-zealand)

4.1.4.2 Thermoclines and Sea Surface Temperature

Water temperatures vary considerably over the year (as seen below) and during spring and summer thermal stratification of the water column becomes evident as a result of solar heating of the upper water column. 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 and usually breaks down towards the end of autumn or during stormy weather, creating isothermal conditions.

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).

Monthly averaged sea surface temperatures have been provided from the Māui A platform which is indicative for the Waru Operational Area. These results are presented below:

- January – 18.13°C;
- February – 19.01°C;
- March – 18.44°C;
- April – 17.60°C;
- May – 16.43°C;
- June – 15.05°C;
- July – 14.01°C;
- August – 13.43°C;
- September – 13.51°C;
- October – 14.02°C;
- November – 15.05°C; and
- December – 16.47°C.

In the STLM undertaken by Curtin University (Appendix 5) a representative sound velocity profile for the summer months of the southern hemisphere was used to obtain the best estimate of the environmental conditions at the time 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 and the profile clearly shows a mixed layer of almost constant sound speed down to a depth of about 20 m, and below this depth there is a reduction of sound speed to 50 m (Koessler & Duncan, 2014).

4.1.5 Geological Setting

A sedimentary basin is formed by a depression in the earth's crust into which sediments have been deposited over millions of years. Within NZ, the sedimentary basins that are likely to contain oil and gas are young (<80 million years) and most have many faults that offset the rock layers.

NZ's key sedimentary basins started forming after the breakup of Gondwana (~85 million years ago) and the opening of the sea floor in the Tasman Sea. Erosion of land by rivers transported sediments containing organic material 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, they made ideal reservoir rocks, while the impermeable overlying silts, mud and carbonates formed the seals.

There are eight sedimentary basins around NZ (Figure 9); both onshore and underlying the continental shelf, with known or potential hydrocarbons present; however, only the Taranaki Basin has produced commercial quantities of oil, gas and condensate. In addition there are also several deep-water basins offshore (Figure 9).

The NZ sedimentary basins can be subdivided into 'Petroleum Basins' and 'Frontier Basins', where 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.

Basin boundaries are mainly determined by major geological structures or seafloor physiography, i.e. regions with stratigraphic continuity and a common geological history are included within a single basin.

Figure 9: NZ Sedimentary Basins
(Source: GNS)

The Waru Operational Area is located within the Taranaki Basin which lies at the southern end of a rift that developed sub-parallel to the Tasman Sea rift, and now separates Australia and NZ. The Taranaki Basin occupies the site of a late Mesozoic extension on the landward side of the Gondwana margin, covering ~ 330,000 km^2 (Figure 10). Within the basin the structure is controlled by the movement along the Taranaki, Cape Egmont and Turi fault zones.

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; which has now increased to over 400 offshore and onshore exploration and production wells drilled in the Taranaki Basin (Figure 10). Over the years there have been a large number of 2D and 3D MSS in the Taranaki region. The proposed Waru 2D MSS will help gather more subsurface information to build onto the existing knowledge of the Taranaki Basin and underlying strata and tie in to the existing data already acquired within PEP 54857.

The Taranaki basin 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. The prevailing west-southwest storm generated waves and currents are most likely the predominant sediment transport agents along the Taranaki coastline.

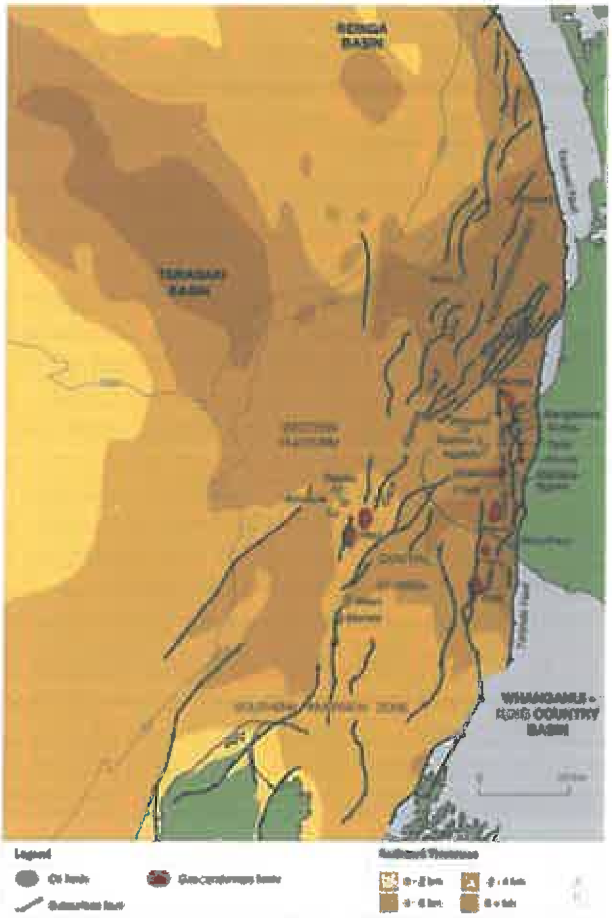

Figure 10: Taranaki Basin
(Source: http://www.nzpam.govt.nz/cms/pdf-library/petroleum-basins/taranaki-basin.pdf)

4.2 Biological Environment

4.2.1 Regional Coastal Environment

The Taranaki region has a coastline that stretches 295 km and is exposed to the Tasman Sea from the west; often resulting in high energy wind and wave conditions. The Taranaki coastline comprises of rocky shores and cliffs, sandy beaches, a marine protected area, two marine reserves, marine mammal sanctuary, subtidal reefs, river mouths and estuaries; providing a wide range of ecological habitats for native plant and animal species. Due to the rugged and exposed nature of the Taranaki coastal environment, much of this coastline has retained its distinctive natural character; this includes natural coastal processes, marine life and ecosystems, coastal landscapes and seascapes.

Taranaki people value the landscape, natural character and amenity recreational values of the coast and is particularly significant for local iwi and hapu as kaitiaki (guardians) of the coast.

The intertidal reef systems along the south Taranaki coastline generally have a lower diversity and abundance of species compared to similar type systems elsewhere in NZ. This is believed to be a result of the high energy wave environment which results in abrasive and turbulent shoreline conditions, high water turbidity, suspended silt and sand inundation. Waters within the South Taranaki Bight are well known for their high turbidity, which is due to fluvial run-of combined with high rainfall. In addition, the energetic wave climate frequently re-suspends sediments, often resulting in prolonged turbid periods, even during dry weather.

Intertidal habitats found around Taranaki are comprised of lahar conglomerate bedrock, boulders, rock pools and occasional sand patches. The rock pools are dominated by some of the large brown seaweeds (*Hormosira banksii, Carpophyllum maschalocarpum* and *Cystophora torulosa*) lower on the shore, whereas the lahar reef is mainly dominated by coralline paint and turf species (TRC, 2006).

Taranaki has more intertidal rocky reefs compared to sandy beaches and those reefs with larger rocks present have a higher species diversity as they provide more habitat and shelter to intertidal species. Taranaki's intertidal shoreline from Urenui around Cape Egmont to Hawera, is almost entirely boulder-lined, consisting of hard andesite boulders, cobbles and pebbles eroded out of the laharic breccias that form the low coastal cliffs (Hayward & Morley, 2004). The laharic breccias were formed by lahars that flowed down from Mt Taranaki and its predecessors creating the ring plan that surrounds the mountain. These breccias consist of andesite clasts set in a matrix of relatively soft volcanic mud and sand, which in many places form a wave-cut low to mid-tidal shore platform on which the boulders and cobbles sit (Hayward & Morley, 2004). The wave-cut platform overlays compacted Pliocene mudstones/siltstone deposits. Periodically large patches of mobile sand is moved inshore and may bury and smother parts of the boulder shore and underlying rock platforms, but this has been a common occurrence over many years along the Taranaki coastline and intertidal species either adapt or rapidly recolonise an area once the sand has moved on.

Over 270 species live on the exposed rocky shores of the Taranaki coastline. At the more exposed northern intertidal reefs and cliffs, biodiversity is low (56 species) due to pounding surf and sand scouring and inundation, while at New Plymouth 180 species are present as the coast becomes more sheltered from Cape Egmont and the substrates are harder and more stable with a greater range of microhabitats (Hayward *et al.*, 1999).

The most common invertebrate species found around the Taranaki coastline consist of several species of mobile gastropods (*Turbo smaragda*, *Melagraphia aethiops*, *Canthridella tesselata* and *Lepsiella scobina*), limpets (*Cellana ornata*, *Cellana radians*, *Notoacmea daedala*), tube worms (*Pomotoceros caeruleus*, *Sabellaria kaiparaensis*), chitons (*Chiton pelisperpentis*, *Amaurochiton glacus* and *Ishnochiton maorianus*), barnacles (*Chamaesipo columna, C. brunnea*), crabs (*Leptograpsus variegatus, Ozius truncatus* and *Petrolithes elongatus*) and anemones (*Isactinia olivacea*, *Isocradactis magna*) (TRC, 2009a; TRC, 2013). These low lying shore platforms and gravel deposits, interspersed with boulders extend subtidally, and inshore of the Waru Operational area are believed to extend offshore for about 3 km to depths of approximately 20 m, while the boulder beaches are interspersed with scattered sand beaches. Beyond 3 km from shore the boulders and reef areas give way to extensive sand dominated areas with occasional shelly material and coarse gravels.

Offshore habitats vary from sand and muddy bottoms to the volcanic platforms and rocky reefs. The inshore Taranaki marine environment provides a wide range of different habitats for a number of aquatic species such as snapper, blue cod, gurnard, warehou, trevally, moki, tarakihi, kahawai, starfish, sea anemones, crabs, crayfish, sea cucumbers, mussels, pipi, paua, octopus, squid, sponges whelks and a number of seaweed species. However, the nearshore subtidal area often supports a low diversity of plant and animal species as a result of high energy wave action, highly turbid water and episodic sand inundation of reefs. A subtidal survey was undertaken for the Kupe Field development to the southeast of the Waru Operational Area and it found that no living organisms were found in the randomly selected samples and observations along the low tide mark failed to identify any signs of life (e.g. bioturbation of worms, crab tracks etc.) along the soft shore section of the site investigated (Mead *et al.*, 2004).

Estuaries and river mouths make up 16% of Taranaki's 295 km coastline, which are shallow, sheltered areas of extremely productive nursery habitats for a variety of marine life. The soft substratum – consisting of productive topsoil carried down by rivers mixed with detrital materials (e.g. leaves), supports a range of burrowing animals such as worms, cockles and pipis. Estuarine areas are ideal refuges for juvenile fish of many species. They also provide essential nesting, breeding and feeding habitats for other native wildlife – particularly in relation to birds.

There are certain areas of the Taranaki coastal environment that are considered to have outstanding coastal value and are outlined in the Taranaki Regional Coastal Plan (TRC, 2009b) and the Taranaki Regional Council inventory of coastal areas of local or regional significance in the Taranaki region (TRC, 2004).

These significant areas are further discussed in Section 4.2.13. The Sugar Loaf Island Marine Protected Area (SLIMPA), Paraninihi and Tapuae marine reserves have statutory protection and are managed for conservation purposes; however there are other coastal areas, without formal protection which are considered by the Taranaki community to be of outstanding coastal value (i.e. Tongaporutu and Mohakatino coastline in the north and Waitotara and Whenuakura estuaries in the south).

4.2.2 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, 2014a).

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, they travel with the ocean currents although some plankton species can move vertically within the water column. Nutrient concentrations 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 CO_2 dissolved in the ocean and help sustain the life of the ocean; and
- Zooplankton – consists of small protists, metazoans (i.e. crustaceans), larval stages of fish and crustaceans and 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.

During spring and summer, cold nutrient rich water from the Kahurangi shoals off Cape Farewell create highly productive plumes that propagate north to the South Taranaki Bight. These upwelling events are intermittent and driven by strong westerly wind events which are common to the region (Shirtcliffe *et al.*, 1990). These onshore winds upwell nutrient rich water from depths of about 100 m, creating rotating eddies that are transported downstream (north and northeast) with a life span of > two weeks (Foster & Battaerd, 1985; Shirtcliffe *et al.*, 1990). As the phytoplankton are entrained within this cold nutrient-rich water they begin to reproduce rapidly and often results in phytoplankton and zooplankton blooms. By the time these eddies reach the Taranaki region they are often nutrient-depleted and phytoplankton-rich and contains high levels of chlorophyll-α; an indicator for plankton productivity, and during spring and summer months this phase is cyclical.

It has been shown that the Taranaki Bight and Cook Strait areas have some of the most extensive zooplankton biomass (exceeding 300 mg m^{-3}) of all coastal regions in NZ (Shirtcliffe *et al.*, 1990). The euphausiids *Nyctiphanes australis* is a common zooplankton species in this upwelling system, and found most abundantly downstream of the upwelling area (Bradford & Chapman, 1988). The sampling locations within Bradford & Chapman (1988) did not extend up into the Waru Operational Area so no empirical data is present on the zooplankton composition within this area, however based on their findings and trends in results it is possible that *N. australis* are present within the offshore section of the Waru Operational Area due to plumes carried downstream from the upwelling area (Torres, 2012).

It has been shown in a number of studies around the world that increased sightings of foraging blue whales occur in association with dense aggregations of euphausiids which form downstream of cold water coastal upwelling systems due to wind-forcing currents and euphausiids biology. It appears from the MMO observations from MSS's undertaken in the South Taranaki Bight and studies on the zooplankton concentrations in the Greater Cook Strait and South Taranaki Bight environment that blue whales and high concentrations of euphausiids can be found within the South Taranaki Bight year round. Torres (2012) compared the observation results of blue whales in the South Taranaki Bight to the chlorophyll-α concentrations and found that there was a higher number of sightings during June and November which correlated to increased primary productivity relative to sightings in other months. However, a MSS acquired in March 2013 also found large numbers of blue whales present where they were observed to be foraging, milling, resting and travelling. Large patches of krill were observed in the water during this particular MSS. However, following a period of bad weather during the survey, the number of whales decreased and was correlated with a decreased distribution of the euphausiids the whales were feeding on. It is most likely that the rough weather broke up the aggregations of euphausiids the blue whales were feeding on and reduced the upwelling conditions and thermocline present which had resulted in the bloom conditions.

The Waru 2D MSS will be acquired in mid-March 2014 where there could be high levels of euphausiids present in the South Taranaki Bight as a result of upwelling events, although from the summary above it is shown this is entirely weather dependent. Weather conditions play an important factor in phytoplankton and zooplankton distribution and abundance (Viner & Wilkinson, 1987; Ghosal *et al.*, 2000; Fujii & Yamanaka, 2008). Settled weather during summer months generally leads to the establishment of well-defined thermoclines, while the presence of westerly winds at the Kahurangi shoals has been shown to lead to the upwelling of cold nutrient rich water to the warmer surface waters in the greater Cook Strait and South Taranaki Bight no matter what time of year. However, rough weather can break up thermoclines and cause vertical migration within the water column; often dispersing any large aggregations of phytoplankton and zooplankton (Viner & Wilkinson, 1987; Ghosal *et al.*, 2000; Fujii & Yamanaka, 2008). As a result zooplankton being more widely dispersed and less concentrated in surface waters may be harder to capture for large animals.

At the end of January 2014, NIWA identified large numbers of blue whales in the South Taranaki Bight that were observed to be feeding on krill. Feeding blue whales were also observed off the Waikato coast during the Anadarko drilling campaign when MMO's were onboard during the vertical seismic profiling.

There could be large aggregations of euphausiids present in the South Taranaki Bight during the Waru 2D MSS, although this appears to be weather dependent. If large aggregations of zooplankton are present in the South Taranaki Bight coinciding with the Waru 2D MSS, studies have shown that mortality of these communities can occur within 5 m of the acoustic source (DIR, 2007). Although due to the location and depth of the Waru Operational Area, it is likely that any large aggregations of zooplankton would only be present on the outer part of the Waru Operational Area. However, if these zooplankton were present within the Waru Operational area, given the large planktonic populations and their high natural mortality rate from stochastic events; any mortality imposed on these communities within close proximity to the acoustic source would be considered negligible.

4.2.3 New Zealand Marine Environmental Classification

MfE, MPI and DOC commissioned NIWA to develop an environmental classification called the NZ Marine Environment Classification (MEC). The MEC 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 (NZMEC, 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 Waru Operational Area falls within MEC groups 60 and 64 representing the shallow to moderately shallow waters on the continental shelf (Figure 11), and are further described below:

- **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* concentrations. 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 64**: occupies a similar geographic range as Class 60 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* concentrations reach the highest concentrations in this class. Some of the more 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.

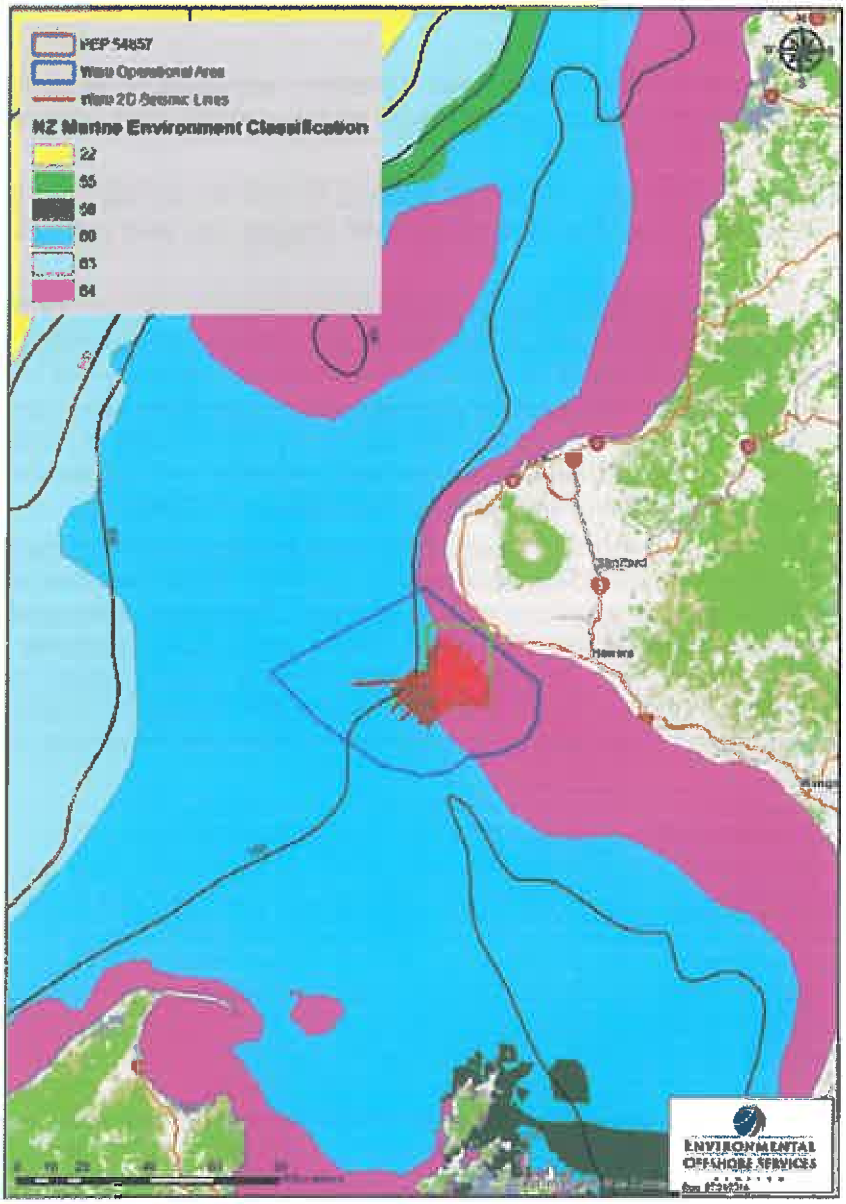

Figure 11: The NZMEC at the 20-class level

4.2.4 Fish Species

In the South Taranaki Bight fish populations comprise of various demersal and pelagic species, which have a wide distribution across NZ – from shallow to deeper waters over the shelf break. General distribution of fish species around the Taranaki coastline and South Taranaki Bight, including waters well offshore from the Waru Operational Area are listed in Table 4.

During summer months, warmer water moves south, bringing with it a number of pelagic species to the Taranaki coastline that are following the abundance of food within the warmer currents. Pelagic species commonly encountered are sunfish, marlin, tuna (albacore and skipjack) and sharks (mako and blue).

MPI prepared a fisheries assessment for NZOG for the Waru 2D MSS. This assessment identified jack mackerel and barracouta are the two most commonly caught commercial fish species within this area (Section 4.4.2).

Table 4: Distribution of fish species around the Taranaki coastline

Water column	Likely fish species
Pelagic	Albacore tuna, skip jack tuna, southern bluefin tuna, mako sharks, blue sharks, and marlin.
Shallow to mid-shelf (<200 m)	Snapper, trevally, kahawai, gurnard, blue warehou, blue cod, blue nose, john dory, hapuku, rig, school shark, spiny dogfish, blue mackerel, jack mackerel, barracouta, leather jacket, red cod, tarakihi and kingfish.
Coastal shelf region (<500 m)	Elephant fish, school shark, giant stargazer, Gould's and Sloan's arrow squid, tarakihi, red cod, frost fish, silver dory, gem fish, barracouta, hapuku, spiny dogfish, red bait, rig and jack mackerel.
Waters < 800 m	Bass, hake, ling, spiny dogfish and hapuku.
Deep water < 1,500 m	Ling and hoki

4.2.5 Threatened Marine Species

Under the NZ threat classification list, NZ has 368 threatened marine species. This includes 4.5% of the seaweeds, 2.4% of the invertebrates, 4.2% of the fish and 62.3% of NZ's 122 species of seabirds (excluding waders and shorebirds) (Hitchmough *et al.*, 2005). Eight of NZ's 50 species of marine mammals are also threatened (Hitchmough *et al.*, 2005; Baker *et al.*, 2010).

Great white sharks occur throughout Taranaki waters and are at risk of extinction and are classified as being in gradual decline under the NZ Threat Classification System and as 'vulnerable' by the International Union of Conservation of Nature (IUCN). They are fully protected in NZ waters under the Wildlife Act 1953 and are further protected on the high seas under the Fisheries Act, prohibiting NZ flagged vessels taking great white sharks beyond the EEZ. Satellite tagging of NZ great white sharks has shown that they 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) (DOC, 2014a). The movement patterns of the tagged great white sharks that are available online do not appear to go anywhere near the Waru Operational Area. Within NZ waters other protected marine species include: basking sharks, whale shark, oceanic whitetip shark, deepwater nurse shark, manta ray and spiny-tailed devil ray.

4.2.6 Marine Mammals

There is a diverse community of marine mammals in NZ waters; over half of the world's whale and dolphin species can be found here. Forty one cetaceans (whales and dolphins) and nine species of pinnipeds (seals) have been recorded in NZ waters (Suisted & Neale, 2004). Whales are further divided into two main types: toothed whales and baleen whales. Baleen whales are often large and generally solitary animals; they don't have teeth, 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 (DOC, 2007). However, most of the whale species are toothed whales and generally spend their life in social groups, communicating with each other using underwater vocalisations or sound.

NZOG acquired two seismic surveys off the Taranaki coastline, west of Cape Egmont in 2013. In April 2013, the Kokako 3D MSS was acquired over a 20 day period within PEP 53473 where there were 23 detections of marine mammal pods, which represented a minimum of 262 animals. These numbers were dominated by a single pod of common dolphins with at least 200 individuals. Of the 23 marine mammal pods detected, eight were classified to the species level and included NZ fur seals, pilot whales, killer whales and blue whales. The blue whale pod comprised of three individuals, and this observation was made when the seismic vessel was off location, to the west of the Operational Area; the acoustic source was not activated and there was no apparent reaction to the seismic vessel. The distance that these blue whales were observed from the source vessel was 483 m. There were 12 groups of unidentified baleen whales observed both inside and outside of the mitigation zone, where one shutdown resulted. With the knowledge that blue whales potentially are in the general South Taranaki Bight area, it is likely that these unidentified baleen whales were in fact blue whales. Given the distance of some of these sightings from the source vessel (~2 – 4 km) it is unknown whether they were avoiding the survey area due to the mitigating source or that is just where they were in relation to the seismic vessel at that time. However, given the small survey size, it makes it difficult to determine any definitive conclusions from the observational data, but in time as the number of MMO reports are collated, this may change.

Following the Kokako 3D MSS, NZOG acquired the Karoro 3D MSS at the end of April 2013 over an 11 day period within PEP 52593. Weather conditions were poor during the MSS, with only two acoustic detections of marine mammal pods (one odontocete, one delphinid), representing a minimum of four animals.

For the preparation of this MMIA, the National Aquatic Biodiversity Information System (NABIS) database was accessed as well as the DOC sighting database, DOC stranding database and available literature to identify potential marine mammal species which could potentially be encountered throughout the Waru Operational Area (MPI, 2014b). The NABIS database has collated records and data from marine mammal sightings, strandings and DOC to identify the locations where each marine mammal species could occupy. The marine mammal species identified that could be present or transitory in the vicinity of the Waru Operational Area are listed in Table 5 with a basic ecological summary of some of the more common and likely marine mammal species to be present summarised below.

Table 5: Marine mammals likely to be present in or around the Waru Operational Area

Whales	Dolphin Family	Pinnipeds
Humpback whale (*Megaptera novaeangliae*)	Common dolphin (*Delphinus delphis*)	NZ fur seal (*Arctocephalus forsteri*)
Blue whale (*Balaenoptera musculus*)	Killer whale (*Orcinus orca*)	
Bryde's whale (*Balaenoptera edeni*)	Bottlenose dolphin (*Tursiops truncates*)	
Fin whale (*Balaenoptera physalus*)	Maui's dolphin (*Cephalorhynchus hectori maui*)	
Minke whale (*Balaenoptera acutorostrata & B. bonaerensis*)	Long-finned pilot whale (*Globicephala macrorhynchus*)	
Sei whale (*Balaenoptera borealis*)	Hector's dolphin (*Cephalorhynchus hectori*)	
Southern right whale (*Eubalaena australis*)	Dusky dolphin (*Lagenorhynchus obscurus*)	
Toothed Whales		
Beaked whales (11 species)		
Sperm whale (*Physeter macrocephalus*)		
Pygmy sperm whale (*Kogia breviceps*)		

As discussed in Section 4.2.5, eight species of marine mammal have been included in the NZ threat classification list; either as nationally critical, nationally endangered or range restricted (Table 6) (Baker *et al.*, 2010). Six species have been identified that could be present within the Waru Operational Area during the Waru 2D MSS (Bryde's whale, killer whale, Maui's dolphin, southern right whale, Hector's dolphin and bottlenose dolphin).

During spring most of the large 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) (DOC, 2007). The distribution and migration paths around NZ for humpback, sperm, Bryde's and southern right whales are shown in (Figure 12). The northern migration routes back up to the Pacific Islands are relatively well known, however the southwards routes are not.

Figure 12: Whale distribution and migration pathways in NZ waters
(Source: http://www.teara.govt.nz/en/map/7052/whales-in-new-zealand-waters)

The DOC sighting database, current up until the end of 2013 had the geographical positions of 2,600 sightings of marine mammals, of which MSS's around the Taranaki coastline have contributed significantly to this database and have been utilised as part of the assessment within this MMIA. The database was plotted on GIS mapping software to see distributions of marine mammals around NZ, however care has to be taken with sighting data, as the lack of sightings does not mean the marine mammals do not reside there, only the fact that there is either little boating activity in that particular area, no observations have occurred during dedicated observational surveys, are beyond easily accessible areas of coastline/harbours or that sighting information has not been submitted to DOC.

The DOC stranding database has also been accessed up until the end of 2013 and plotted on GIS mapping software which has been used as part of the assessment for potential marine mammal species within the Waru Operational Area. 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.

Pilot whales are the most frequent herd stranders of all cetaceans with the largest single stranding recorded in NZ was 450 whales at Kawa Bay, Great Barrier Island in 1985 (Brabyn, 1991). Farewell Spit has a large number of strandings every summer as the shallow extensive sandy beaches result in a number of whales stranding each year. In January 2014 there were a number of stranding events, with a large number refloated, however a number also died or were euthanased.

The DOC database of marine mammal strandings and observations in relation to the Waru Operational Area are plotted below in Figure 13. There has been three recorded observations of blue whales in the Waru Operational Area, so it is likely that they could be observed during the Waru 2D MSS, especially if the weather conditions result in upwelling providing an abundance of krill in the South Taranaki Bight during the MSS period.

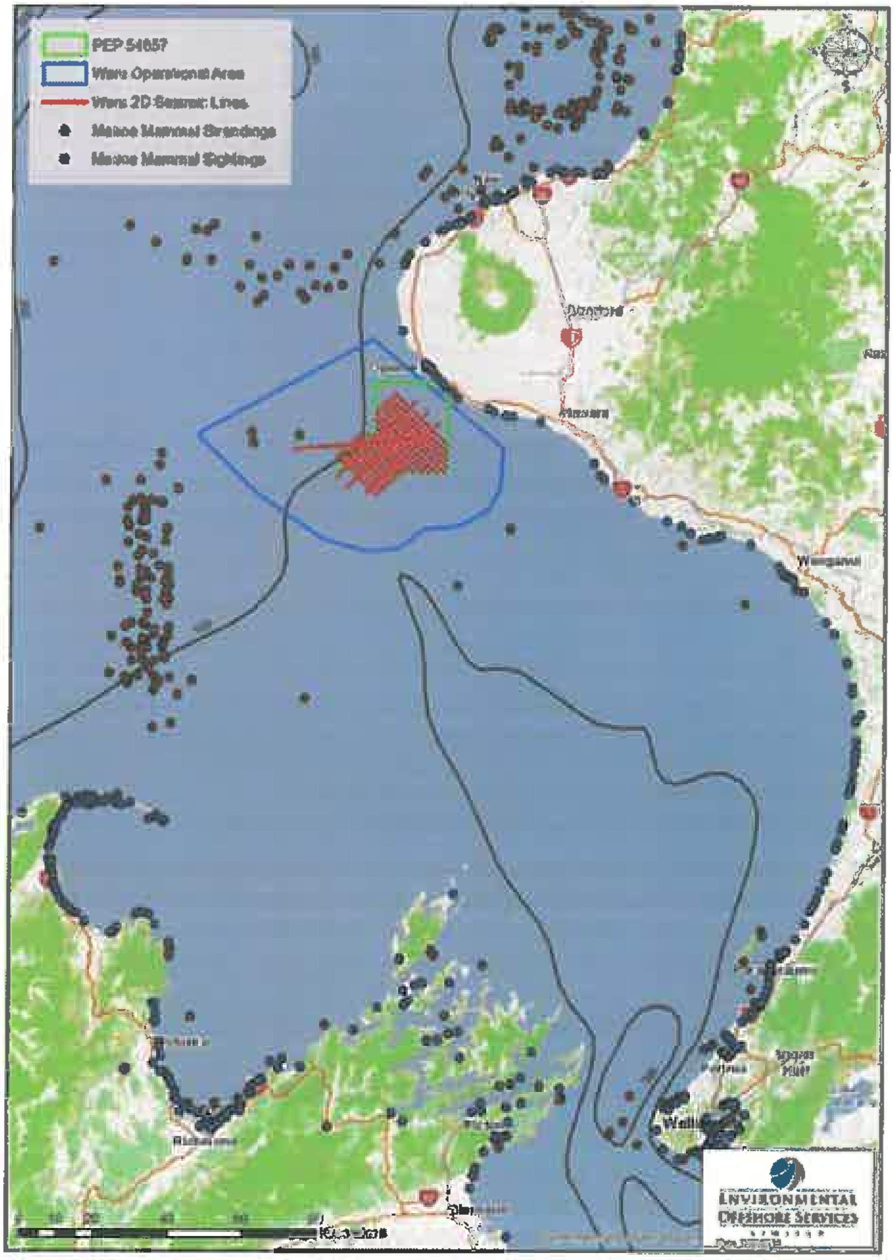

Figure 13: DOC records of marine mammal strandings and sightings

Table 6: Marine mammals on NZ threat classification list (DOC, 2007; Baker *et al.*, 2010)

Marine Mammal Species	NZ Threat Classification	IUCN Classification	Summary	Distribution	Likely to be in Survey Area
Bryde's whale *(Balaenoptera edeni)*	Nationally critical	Data deficient	Generally a coastal species but do also live in the open ocean. Bryde's whales prefer temperate waters and are observed off the NZ coast generally north of the Bay of Plenty. This species of whale is believed to rarely venture beyond 40 degrees south.	Have a preference for warmer waters, they have been observed in the wider Taranaki waters during summer months.	✓
Killer whale *(Orcinus orca)*	Nationally critical	Data deficient	Feeds on a variety of animals which include other marine mammals and fish species. They are believed to breed throughout the year and appear to migrate based on the availability of prey.	Largely unknown but tend to travel according to the availability of food. Killer whales are widely found in all oceans of the world although more dominant in cooler waters. Have previously been observed in Taranaki waters. Likely to occur in the Waru Operational Area.	✓
Maui's dolphin *(Cephalorhynchus hectori maui)*	Nationally critical	Critically endangered	World's smallest dolphin and found in inshore waters on the west coast of the North Island. Considered a subspecies of Hector's dolphin	Generally live close to shore (within 4 nautical miles) although the 100 m depth contour has been indicated as being their offshore distribution given current scientific understanding. Only found in the North Island. Could possibly occur in the Waru Operational Area. If any observations were made DOC would be notified immediately.	✓
Southern elephant seal *(Mirounga leonina)*	Nationally critical	Least concern	They are the largest species of seal and feed 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 lives mostly at sea. They have an inflatable proboscis (snout) which is most present in adult males which is meant to increase the bull elephant seals roar.	Primary range includes the Antipodes, Campbell, Auckland, Snares Islands and the surrounding Southern Ocean. Occasionally they are found on the mainland from Stewart Island to the Bay of Islands. Not likely to occur in the Waru Operational Area.	×
Southern right whale *(Eubalaena australis)*	Nationally endangered	Least concern	Present both offshore and inshore and their diet consist of krill, particularly copepods. Mate and calve during winter months in sheltered sub Antarctic harbours such as Auckland Islands and Campbell Island. Are baleen feeders and often travel well out to sea during feeding season; but they give birth in coastal areas (American Cetacean Society, 2010).	Likely to occur as a transient species in the Waru Operational Area.	✓
Hector's dolphin *(Cephalorhynchus hectori)*	Nationally endangered	Decreasing	One of the smallest dolphin species (less than 1.5m long). Generally live inshore although have been sighted up to 18 Nm from the coast. Little known about migratory, reproductive, or feeding habits.	Patchily distributed around the South Island coast. Strandings have occurred along the Taranaki coastline. Could possibly be observed in the Waru Operational Area due to their affinity for inshore waters, where the 100 m depth contour has been indicated as being their offshore distribution given current scientific understanding.	✓
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/January with the pups being weaned in July/August.	Known to forage along continental shelf breaks with primary range including the Auckland, Campbell, and Snares Islands. Unlikely to be encountered in the Waru Operational Area.	×
Bottlenose dolphin *(Tursiops truncatus)*	Nationally endangered	Least concern	Are found worldwide in temperate and tropical waters, generally north of 45 degrees south. Population density appears to be higher near shore. Resident bottlenose dolphins are found off the east coast of the North Island, the northern tip of the South Island, and in Doubtful Sound.	Possibly observed in the Waru Operational Area.	✓

4.2.6.1 Humpback Whale

Humpback whales are a baleen whale belonging to the rorqual family; the head is broad and rounded but slim in profile, a round body shape and unusually long pectoral fins. The top of the humpbacks head and lower jaw have rounded bump-like knobs which have at least one stiff hair, believed to help detect movement in nearby waters. During summer humpbacks feed in polar waters for up to 80 – 100 days and can consume up to two tonnes of krill per day; then in winter migrate north to tropical or sub-tropical waters (i.e. Tonga) for mating and calving where they fast and live off their fat reserves built up from the polar region. Whaling in the southern hemisphere reduced the population from ~120,000 animals to 15,000 but the population is now currently recovering (Suisted & Neale, 2004).

The migration route of humpbacks sees them travel from their summer feeding grounds in the Antarctic up the east coast of the South Island, 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). DOC undertake a Cook Strait whale monitoring project in June – July each year to coincide with the northern migration of the humpback whales to the South Pacific Breeding grounds. This migration north will occur after the Waru 2D MSS is complete.

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

Sighting records and the DOC database has shown that humpback whales are present around the Taranaki coastline, however it is likely that this area is mainly used as a migratory pathway for the humpback whales as they travel north or south along the west coast of NZ (Torres, 2012).

4.2.6.2 Blue Whale

Blue whales are the largest animals to ever live; adults can reach up to 33 m long and weigh up to 150 tonnes (Croll *et al*., 2005). They are long-lived, slow reproducing animals and it is estimated that fewer than 2,000 blue whales can be found in the southern hemisphere. There are only four blue whale foraging areas documented in the Southern Hemisphere outside Antarctic waters (Torres, 2013). During summer they travel to their feeding grounds in the Antarctic while in winter they spend their time in equatorial waters.

Despite blue whales being such large animals, they are fairly elusive and little is known about their distribution or habitat use patterns. Torres (2013) published a paper on a previously unrecognised blue whale foraging ground in the South Taranaki Bight and completed two research voyages to the South Taranaki Bight in January/February 2014 to further study the blue whales. In the first voyage on 28th – 29th January 2014 they observed 47 blue whales and were able to take 9 biopsy samples, faecal samples, krill samples, oceanographic sampling with a conductivity, temperature, depth (CTD) instrument and took hundreds of photographs and video footage. Observations were made of the blue whales lunge feeding on the large krill swarms at the surface. Blue whales have been observed in the South Taranaki Bight during MSS programmes over recent years, and appear to be using this area to feed on krill as a result of the upwelling from the Kahurangi shoals. These MSS's which have observed a number of blue whales have been spread throughout the following months: July 2010, May-July 2011, March-April 2012, Feb-April 2013, January 2014, and February 2014. As a result of these observations over recent years it is assumed that blue whales could be observed at any time throughout the year in the South Taranaki Bight. The waters north of Cook Strait and within the South Taranaki Bight therefore appear to be an important foraging area on their migratory pathway. Blue whales have the highest prey demands of any predator and can consume up to two tonnes per day (Rice, 1978; DOC, 2007), therefore large aggregations of food in upwelling areas is important to these whales.

Blue whales can feed at depths of more than 100 m during the day and surface feed at night due to the distribution of krill which they feed on (Wikipedia, 2014a). Dive times are typically ten minutes when feeding, although dives of up to 20 minutes are common. Blue whales feed by lunging forward at aggregations of krill, taking the krill and a large quantity of water into its mouth. Excess water is squeezed out through the baleen plates by pressure from the ventral pouch and tongue. Once the mouth is clear of water, the remaining krill, unable to pass through the plates, are swallowed.

In the Southern Hemisphere there are two subspecies of blue whales; Antarctic (or true) blue whales and pygmy blue whales but they are difficult to distinguish at sea so it is not surprising that all sightings have been recorded as blue whales. Pygmy blue whales are present off the Taranaki coastline; a 22 m pygmy blue whale was washed ashore at Waiinu Beach along the South Taranaki Bight on 30 April 2011 and a 20 m pygmy blue whale at Himatangi Beach in October 2013. It is possible that both sub-species of blue whale use this South Taranaki habitat, but only further research will confirm this, such as testing of genetic samples from the NIWA blue whale survey in the South Taranaki Bight undertaken in January 2014.

Antarctic blue whales are generally found south of 55°S during the Austral summer, while pygmy whales are believed to remain north of 54°S (Branch *et al.*, 2007). It has been assumed that Antarctic blue whales migrate to temperate waters for mating and calving during the winter and return to the Antarctic in the summer months for feeding (Torres, 2012). However, there is recent evidence around the world from a number of locations (including NZ) that some Antarctic blue whales do not migrate south every winter (Branch *et al.*, 2007). The distribution of pygmy blue whales has been documented to show that they do migrate to Antarctic waters during summer. Torres (2012) undertook an analysis of marine mammal strandings in NZ, and up to 1991 it was shown that five of the 11 blue whale stranding events in NZ occurred around the Farewell Spit, South Taranaki Bight and Cape Egmont region. It was proposed in Torres (2012) that during summer months when blue whales have been observed in the South Taranaki Bight; given most of the Antarctic blue whales are believed to be feeding in Antarctic waters, that the sighting of blue whales in the South Taranaki Bight are likely to be pygmy blue whales.

The IUCN red list of threatened species currently lists the Antarctic blue whale as *Critically Endangered* and the pygmy blue whale as *Data Deficient*. However under the NZ threat classification system blue whales are currently classified as a 'migrant' and therefore does not designate a threat status (Torres, 2013) but are listed as a Species of Concern under the Code of Conduct. Although 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.

Blue whales vocalise at a low frequency (0.01 – 0.04 kHz); resulting in their vocalisations being able to travel a very long distance through the water. This distance, which can be up to a couple of hundred kilometres, is a result of efficient propagation of a low-frequency sound emitted in water and is the reason that MSS emit low frequency acoustic signals to penetrate down through the seabed. The communication calls of blue whales partially overlap with the acoustic energy emitted from MSS (Table 8). Blue whale vocalisations are also very loud, where their calls can reach levels of up to 188 dB (WDCS, 2014; WWF, 2014). It has been shown that blue whales will increase their calls (emitted during social encounters and feeding) when a MSS is operational within the area (Section 5.1.2.5). It is believed that blue whale increases their calling when a MSS is operational to increase the probability that communication signals will be successfully received by conspecifics and compensate for the masking of communications by noise (Di Iorio & Clark, 2009).

4.2.6.3 Bryde's Whale

Around the NZ coastline Bryde's whales are the most common baleen whales. Given they prefer warmer waters (above 20°C) they are generally found in northern NZ (Suisted & Neale, 2004). During the Waru 2D MSS the average water temperature for March 2014 within the Waru Operational Area is expected to be 18.44°C (Section 4.1.4.2). Bryde's whales are the second smallest baleen whale within NZ waters; they can grow up to 12 – 15 m in length and weigh up to 16 – 20 tonnes. Bryde's whales are distinct to other baleen whales in the polar regions; as they will also feed on fish (pilchards, mackerel and mullet). There has only been one sighting of a Bryde's whale in Taranaki waters (Torres, 2012) and one stranding record on the coast between Wanganui and Patea; so the potential for observing them during the Waru 2D MSS is likely to be low but is possible.

4.2.6.4 Minke Whale

There are three species of minke whales: the northern minke (*Balaenoptera acutorostrata*) (confined to northern hemisphere), the Antarctic or southern minke (*Balaenoptera bonaerensis*) and a sub-species, the dwarf minke which is present in NZ waters. The southern minke is confined to the southern hemisphere, including NZ, and although most commonly observed south of NZ feeding in Antarctic waters, they have been observed close to shore at Cape Egmont. A number of Minke whales have stranded at Farewell Spit and Golden Bay as well as along the Wanganui and Kapiti coastlines. Therefore there is the potential that a minke whale could be encountered during the Waru 2D MSS.

4.2.6.5 Sei Whale

Sei whales are a medium sized baleen whale with an average length of 15 – 18 m and weigh 20 – 25 tonnes. Sei whales are among the fastest swimming cetaceans; swimming at speeds of 50 km/hr and have travelled 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 and Chatham Islands to calve. Occasional observations have been made over the summer months in the South Taranaki Bight but there has been no strandings in the vicinity of the South Taranaki Bight, so although the Sei whales are likely to be either in or on their way to Antarctic waters, they could potentially be observed during the Waru 2D MSS.

4.2.6.6 Southern Right Whale

Southern right whales are a large baleen whale that can grow up to 15 – 18 m in length and the lack of a dorsal fin allows for their easy identification. The upper jaw and facial area of the southern right whale has callosities (hardened patches of skin) that are often white due to infestations from whale lice, parasitic worms and barnacles making them more distinguishable. They are a slow moving whale, often swimming at speeds less than 9 km/hr, making them vulnerable to ship-strikes.

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 (subantarctic and Campbell Islands) to feed. Their northern migration sees them go through the Taranaki region between May-October, although sighting observations have been recorded outside of this period.

The population was heavily reduced by whaling, where numbers dropped from ~17,000 to ~1,000 (Suisted & Neale, 2004; Carroll *et al.*, 2011a) and is a priority for DOC to collect sighting data and genetic samples. Within NZ southern right whales are regarded as nationally endangered but it appears they are making a recovery. Genetic evidence suggests that southern right whales seen around mainland NZ and the NZ subantarctic represent one stock, as there is no differentiation between the two regions based on the analysis of mitochondrial or nuclear loci (Carroll *et al.*, 2011b). It is now thought that there is currently one NZ population of southern right whales with a range that includes two wintering grounds: the primary wintering ground in the NZ subantarctic and secondary wintering ground of mainland NZ (Carroll *et al.*, 201b). 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 through modelling estimated that the whales associated with the survey area during the course of the study was estimated to be 1,286 (689-2,402) in 2011.

Southern right whales have been observed around the Taranaki coastline, where all but one of the nine observations have occurred during the winter period (Torres, 2012) and again all but one of these sightings have been very coastal between Okato and New Plymouth. This seasonal trend depicts the migration cycle of southern right whales, with the winter sightings most likely reflecting animals on breeding or calving grounds (Torres, 2012). This is typical of the southern right whales with a habitat use pattern at this life history stage to be in protected coastal waters with the least threat of predation from predators such as killer whales and sharks (Torres, 2012). A southern right whale sighting has previously been observed within the Waru Operational area, although this was during winter. It is therefore believed an observation of a southern right whale during the Waru 2D MSS is unlikely due to the proposed commencement in March 2014 when these whales are down in Antarctic waters to feed, however it is possible given they are known to frequent these inshore Taranaki waters.

4.2.6.7 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 300 m.

Along the Taranaki coastline seven species of beaked whales have been recorded from the DOC stranding database and include: Blainville's, Gray's, Layard's, Shepherd's, Cuvier's, Arnoux's and pygmy. Due to the relative frequency of beaked whale strandings throughout the year it is assumed they are present all year round and could therefore be observed during the Waru 2D MSS, although they are difficult to observe at sea.

4.2.6.8 Sperm Whale

Sperm whales are globally distributed with all three species found in NZ waters (large, pygmy and dwarf) 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. They are an intelligent animal, with a brain weighing on average 8 kg it is heavier than any other animal (Te Ara, 2014b; Wikipedia, 2014b). Squid is their most common food but they are also known to eat demersal fish (Torres, 2012).

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, so they rely heavily on acoustic senses for navigation and communication (Torres, 2012). Within NZ, the main population of sperm whales resides in Kaikoura and includes both resident and transient individuals. Under the IUCN sperm whales are currently listed as vulnerable.

During summer month's sperm whales migrate to the poles, males more so than females and juveniles, however they have been observed in the deep offshore waters of the South Taranaki Bight over summer months. From the DOC stranding database a large number of sperm whales have been recorded stranded along the south Taranaki, Wanganui and Kapiti coastlines as well as in Golden Bay and Farewell Spit, so they could be observed during the

Waru 2D MSS. Three sperm whale stranding events have been recorded directly inshore from the Waru Operational Area.

4.2.6.8.1 Pygmy Sperm Whale

Pygmy sperm whales (*Kogia breviceps*) are slightly larger than dolphins, they can grow up to 3.5 m in length and weigh 400 kg. Pygmy sperm whales have no teeth in their upper jaw, only sockets, which the 10 – 16 pairs of teeth in the lower jaw fit into.

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. As a result most of the knowledge on these whales is derived from stranded whales.

Over recent years pygmy sperm whales have stranded ashore along the Wanganui and South Taranaki coastlines; a whale washed ashore at Waiinu Beach in May 2011, in February 2013 there was a stranding in the entrance of the Raglan Harbour, and a whale washed ashore at Ototoko Beach, Whanganui in October 2013 indicating their presence along the general west coast of the North Island. The DOC stranding database has shown a number of pygmy sperm whales have stranded along the shore from Waverley Beach south to Wellington indicating this species is relatively common along this stretch of coastline. Therefore, it is assumed that pygmy sperm whales may be present in the Waru Operational Area, but they could be difficult to observe in most sea conditions.

4.2.6.8.2 Dwarf Sperm Whale

Dwarf sperm whales (*Kogia sima*) are rare in NZ waters (Te Ara, 2014b) and are not often sighted at sea, with most of the known information on this species derive from stranded whales. The dwarf sperm whales are the smallest species commonly known as a whale, where they can grow up to 2.7 m in length and weigh up to 250 kg, often smaller than some of the larger dolphins. These whales make slow, deliberate movements with little splash or blow and usually lies 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 is slightly smaller and has a larger dorsal fin. The DOC stranding database only has four records of dwarf sperm whales and they have been in the Auckland and Northland region, indicating it is unlikely that this species would be observed during the Waru 2D MSS.

4.2.6.9 Maui's Dolphin

Maui's dolphins are the world's smallest dolphin and are only 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, believed to be a sub-species of Hector's dolphins, are a protected species; classified as 'nationally critical' in the NZ threat classification and 'nationally endangered' by the IUCN. It is estimated that the population of Maui's dolphins is 55 (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). During the Hamner *et al.* (2012) study, two female Hector's dolphins were observed in the North Island from the west coast South Island population and was the first documented contact between these two species and indicates there could be the potential for interbreeding.

Maui's dolphins have a coastal distribution, generally in water depths of less than 20 m as most sightings occur within 4 Nm of the coastline (Figure 14), although they have been sighted up to 7 Nm from the shore (Du Fresne, 2010) and at 19 Nm from the Māui A platform, however, this sighting must be treated with caution as it was a public sighting without photo/video evidence.

Over the last ten years mammal surveys have extended well south of Raglan and Kawhia but no Maui's dolphins have been observed (Ferriera & Roberts, 2003; Slooten *et al*., 2005; Webster & Edwards, 2008). Possibly due to these areas being beyond the core range of Maui's dolphins, although visited occasionally, or there are Maui's dolphins resident in these southern areas but the surveys just missed them due to their low numbers (Du Fresne, 2010). However there is evidence that Maui's/Hector's dolphins visit the stretch of Taranaki coastline from reports of a Maui's/Hector's dolphin 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 Waru 2D MSS is being acquired in water depths of 50 – 100 m and is located within the AEI so there is the potential that a Maui's dolphin could be observed. There is also the potential that Maui's/Hector's dolphin could be observed in the Waru Operational Area moving between the west coast South Island and west coast North Island populations.

If a Maui's dolphin sighting was made during the Waru 2D MSS, DOC would be notified immediately and it would be highly significant to the distribution and study of this dolphin species. If the sighting was reliable, DOC staff would mobilise a fixed-wing aircraft and the DOC 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 southern extent of Maui's dolphin, their offshore range and whether sightings off South Taranaki/Whanganui are of Maui's or Hector's dolphins.

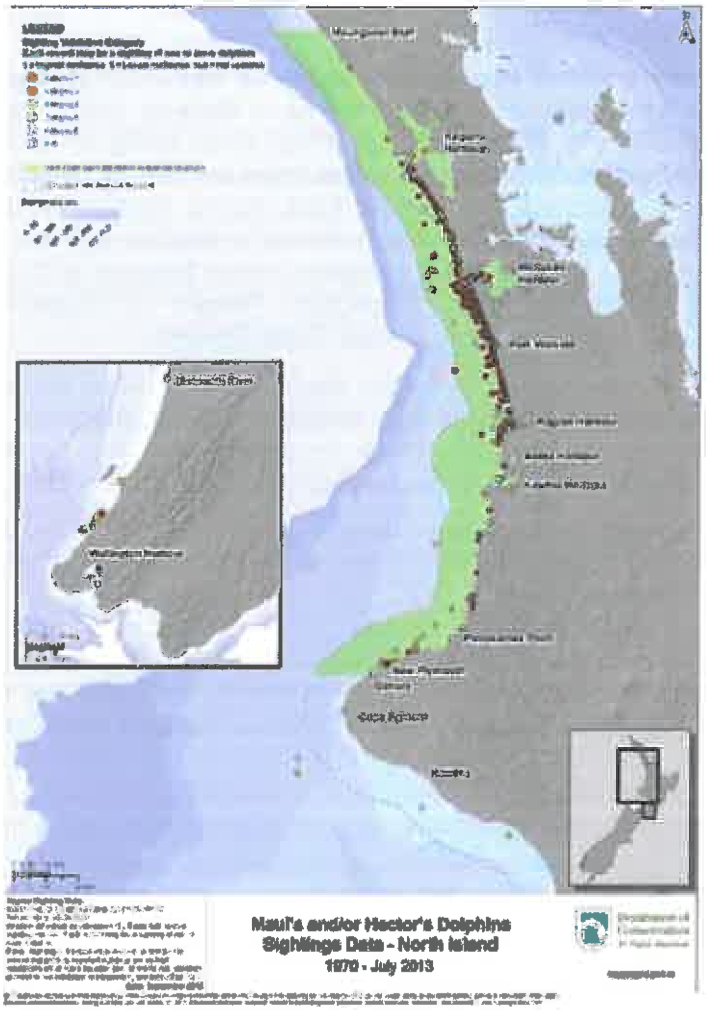

Figure 14: Maui's and/or Hector's dolphin sightings from 1970 – 2013

4.2.6.10 Hector's Dolphin

Like Maui's dolphins, Hector's dolphins are only found in NZ waters and at 1.2 – 1.5 m in length they are one of the smallest cetaceans in the world. Over the last 40 years their numbers have declined significantly - from ~29,000 in the 1970s to ~8,000 and are classified as 'nationally endangered' by the NZ threat classification list and as 'endangered' on the IUCN list as they are among the most rare of the world's 32 marine dolphin species. 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 (MPI, 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). Hector's dolphins have also being observed within the Maui's dolphin area in north Taranaki (Hamner *et al.*, 2012).

MPI funded survey programmes were 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 *et al.*, 2012; MacKenzie & Clement, 2013). The survey programme involved aerial surveys during summer and winter months with the number of Hector's dolphins recorded along transect lines. The sighting data was analysed using mark-recapture distance sampling and density surface modelling techniques to yield estimates of density and total abundance. It was estimated that the south coast South Island population was estimated to be 628 dolphins (95% CI = 301 - 1,311).

For the east coast South Island surveys a total of 354 dolphin groups sighted in summer and 328 dolphin groups sighted in winter. After the results were analysed using the modelling techniques above to yield estimates of density and total abundance, an estimate of 9,130 (95% CI = 6,342 - 13,144) was determined for summer and 7,465 (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).

It is believed set nets used are responsible for ~75% of the known Hector's dolphin's deaths but many more may go unreported (MPI, 2014c; Project Jonah, 2014). Hector's dolphins are often observed close to shore as they prefer shallow, turbid coastal waters with water depths of less than 100 m. However, occasional sightings have occurred beyond the 100 m isobaths at distances out to 20 Nm off Banks Peninsula (MacKenzie & Clement, 2013) and a sighting of a Hector's/Maui's dolphin from the Māui platform. There have been three others within the South Taranaki Bight (Torres, 2012) and could possibly be dolphins moving between the west coast/Marlborough Sounds and west coast North Island populations.

The DOC stranding database shows there have been Hector's dolphins stranded at Farewell Spit, Waikanae, Wanganui, Opunake, and Oakura indicating that this species does move north of the South Island, and as indicated potentially travel north to the west coast of the North Island.

Given the water depth of the Waru Operational Area (50 – 100 m), it is entirely possible that a Hector's dolphin could be present if dolphins were moving between the two different populations.

4.2.6.11 Common Dolphin

Within NZ waters 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). The maximum ages of the common dolphin is up to 29 years old which scientists calculated from a fresh carcass, the oldest on record for this species, with sexual maturity at 7 – 12 years for males and 6 – 7 years for females.

Common dolphins are distributed around the entire NZ coastline, generally remaining within a few kilometres of the coast and can often form groups of several thousand individuals. In the Bay of Islands the mean water depth of sightings is 80 m, but range from 6 – 141 m (Constantine & Baker, 1997). The principal predators of common dolphins are killer whales.

This species of dolphin is common around the Taranaki coastline and has been observed in the South Taranaki Bight (Torres, 2012). The stranding database shows records of dolphins stranding along most of the top of the South Island, especially at Farewell Spit, and the entire stretch of coastline between Wellington and New Plymouth. Given common dolphins generally prefer the coastal waters, they will be observed either in the Waru Operational Area or when the *Aquila Explorer* is mobilising or from the Waru Operational Area.

4.2.6.12 Bottlenose Dolphin

Bottlenose dolphins are among the largest of dolphin species, ranging from 2.4 – 4 m in length and 250 - 650 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 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 are now listed as 'Nationally Endangered' on the NZ threat classification list, largely due to their low abundance and concerns over potential decline in populations.

Bottlenose dolphins have been observed within the South Taranaki Bight (Torres, 2012) with one stranding event recorded on the coast north of Opunake in 2001. The only other strandings in the surrounding waters of the Waru Operational Area have been at Manawatu, Paekakariki, Tasman Bay and Golden Bay.

4.2.6.13 Dusky Dolphin

Dusky dolphins are slightly smaller than common dolphins; growing up to 2 m in length, 50 – 90 kg in weight and are characterised by having virtually no beak. They prefer cool inshore waters but have can be found as far offshore as the continental shelf. In NZ waters they mainly live from East Cape to Kaikoura and are the second largest population of dolphin species around NZ. The population of dusky dolphins within NZ is believed to be 12,000 – 20,000 individuals and are not regarded as threatened (Markowitz *et al.*, 2004). No defined seasonal migrations exist but they are known to make offshore seasonal and diurnal movements. During late spring and summer, dusky dolphins spend the mornings inshore resting and socialising then late afternoon move 6 – 15 km offshore. In winter dusky dolphins generally spend more time in deeper water.

Dusky dolphins consume a variety of fish (e.g. anchovies) and squid species as part of their diet, often forming large feeding groups. Admiralty Bay is regularly used by 200 – 300 dolphins as a winter foraging habitat. Dusky dolphins have been observed in the South Taranaki Bight (Torres, 2012) so they could be observed within the Waru Operational Area.

4.2.6.14 Killer Whale

Killer whales are the largest member of the dolphin family; males can grow to 6 – 8 m and weigh in excess of six tonnes. They have the second heaviest brains among all mammals and are very intelligent. It is believed two populations exist within NZ waters; one inshore and one offshore although this is still not verified. During the summer NZ fur seal breeding season, killer whales are often found inshore.

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 & Neale, 2004). On 12 February 2014 nine killer whales stranded at Blue Cliffs Beach, near Tuatapere (South Coast of NZ) which was a tragic stranding, being NZ's third largest stranding of killer whales and possibly one of the 10 largest internationally. As part of this stranding, Visser was quoted as saying there are fewer than 200 killer whales now living off the NZ coast.

Killer whales do frequent the Taranaki region and generally exhibit a coastal (Torres, 2012), however it is important to note that there are limitations within sighting databases and collecting data on marine mammals that have low numbers with wide temporal and spatial distributions. It is possible that killer whales could be observed within the Waru Operational area or when the *Aquila Explorer* is mobilising to and from the Waru Operational Area.

4.2.6.15 Pilot Whale

Pilot whales are a member of the dolphin family; males are larger than females and can grow up to 6 m long and weigh three tonnes. There are two species of pilot whales; long-finned and short-finned, of which the long-finned is found within 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, which generally peaks in spring and summer (O'Callaghan, 2001), with Farewell Spit renown for a number of whale strandings each year. The most recent have occurred within ten days of each other in January 2014, where two pods stranded at the base of Farewell Spit, some were refloated however a number of the whales either died or were euthanased.

They are a very social whale and can often travel in groups of up to 100; it was originally thought the family relationships among the pilot whales was the cause of strandings as a result of their 'care-giving' behaviour. Where if one or a few whales stranded due to sickness or disorientation, a chain reaction is triggered which draws 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 are abundant within the Taranaki region and South Taranaki Bight (Torres, 2012), and along with common dolphins are one of the most observed cetaceans from recent seismic surveys in the Taranaki region; therefore it is highly likely they will be observed in the Waru Operational Area.

4.2.7 Pinnipeds

Within NZ waters the NZ fur seal is the most common of the pinnipeds. They are distributed around NZ, with a population estimate of 50,000 – 60,000 but this potentially 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 can hold their breath for 10 – 12 minutes, enabling very deep dives (~ 200 m) to feed on fish (small mid water fish, conger eels, barracouta, jack mackerel and hoki), squid and octopus; which is further aided by being able to slow their heart rate down to help conserve oxygen.

NZ fur seals are present year round in offshore Taranaki waters with a continual presence at the offshore Taranaki platforms and Floating Production Storage and Offloading Installations (FPSO) in the South Taranaki Bight. The NZ fur seals spend time hauled out on the platform braces and associated structures when they are not foraging for fish which are attracted to these installations. Several NZ fur seal breeding colonies and haul-out areas are present on the west coast of the North Island; the closest being the Sugar Loaf Island Marine Protected Area (SLIMPA). Their breeding season extends from mid-November to mid-January; the adult males arrive first in late October, followed by females in late November. Pups are usually born in January and weaned in July-August when the females return to sea. It is highly likely that NZ fur seals will be observed within the Waru Operational Area.

4.2.8 Marine Reptiles

Off the coast of NZ, seven marine reptile species are known to live: the loggerhead turtle (*Caretta caretta)*, green turtle (*Chelonia mydas)*, hawksbill turtle (*Eretmochelys imbricate)*, olive Ridley turtle (*Lepidochelys olivacea)*, leatherback turtle (*Dermochelys coriacea*) yellow-bellied sea snake (*Pelamis platurus)*, and the banded sea snake (*Laticauda colubrine)*. Most of the marine reptiles are generally found in warm temperate waters, and within NZ this mainly occurs off the northeast coast of the North Island.

Within Taranaki waters the leatherback turtle and the yellow-bellied sea snake have been observed (DOC, 2014b). These are rare visitors to Taranaki waters and if any reptiles are recorded during the MSS they would be recorded and further increase the knowledge of NZ's marine reptiles. 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.*, 2000).

4.2.9 Seabirds

There are 86 species of seabirds in NZ waters which include albatross, cormorants, shags, fulmars, petrels, prions, shearwaters, terns, gulls, penguins and skuas (DOC, 2014c). NZ is often considered to be the seabird capital of the world and important breeding grounds, with NZ having the greatest variety of albatrosses and petrels. Most of the seabirds identified in this MMIA breed on coastal headlands and offshore islands and some use the Waru Operational Area as foraging habitat.

A number of sources (DOC, NABIS, Kokako & Karoro 3D MSS MMO Reports) have been used to identify the likely seabirds that could be present within and around the South Taranaki Bight and includes:

- **Albatross** – wandering, southern royal, northern royal, light-mantled sooty, antipodean, Campbell, Gibson's, grey headed, Chatham, pacific and white capped;
- **Mollymawks** – Salvins, black-browed and Buller's;
- **Shearwaters** – short tailed, little, Buller's, flesh-footed, sooty, Hutton's, common-diving and fluttering;
- **Petrels** – black, common diving, grey, grey-faced, Kermadec white-faced storm, northern giant, Westland, NZ storm, Giant (Nelly), Cape, Mottled and white chinned;
- **Terns** – Caspian, white and white-fronted;
- **Penguins** – northern little blue and blue; and
- South polar skua, black-backed gull, red-billed gull, black-billed gull, cape pigeon, masked booby, fairy prion and Australasian gannet.

Sea birds that feed by plunge diving (i.e. Australasian Gannet) or that rest on the sea surface and dive for food (i.e. sooty shearwater) have the potential to be affected by underwater noise from MSS's. However it is believed that acoustic damage to birds could only be experienced if a bird was diving in close proximity to the acoustic source array (i.e. within 5 m of the array) (Bendell, 2011).

Diving seabirds are all highly mobile and are likely to flee from approaching sound sources. The potential for physiological effects from MSS noise on diving bird species is considered to be of high intensity but would only be in close proximity to the acoustic source and limited to the MSS duration (~5 days). Likewise, any avoidance behaviour of birds from the Waru Operational Area, if indeed it does occur, would only last for the MSS duration.

It is highly likely that the Australasian Gannet will be in the Waru Operational Area during the proposed commencement date in March; given these birds often follow the sub-tropical water that moves south carrying an abundance of food for the gannets, where gannets can be observed along a large part of the west coast of NZ and throughout the top of the South Island. These birds feed on the pelagic baitfish (i.e. pilchards, saurie, anchovies) that are present in this sub-tropical water, and it is likely that if these baitfish move away from parts of the Waru Operational Area due to the sound levels emitted during the Waru 2D MSS, the likelihood of any seabirds diving in close proximity to the acoustic source is considered remote. Gannets have very good eyesight and only enter the water when they can view these baitfish, often travelling many kilometres until they find food.

4.2.9.1 Breeding Colonies

Surrounding the Waru Operational Area, five bird species are known to have breeding colonies. These birds, listed below along with their listing in the NZ threatened species classification, have their breeding colonies plotted in Figure 15.

- Sooty shearwater – declining;
- Caspian tern – nationally vulnerable;
- King shag – vulnerable;
- Grey-faced petrel – declining; and
- Flesh-footed shearwater – declining.

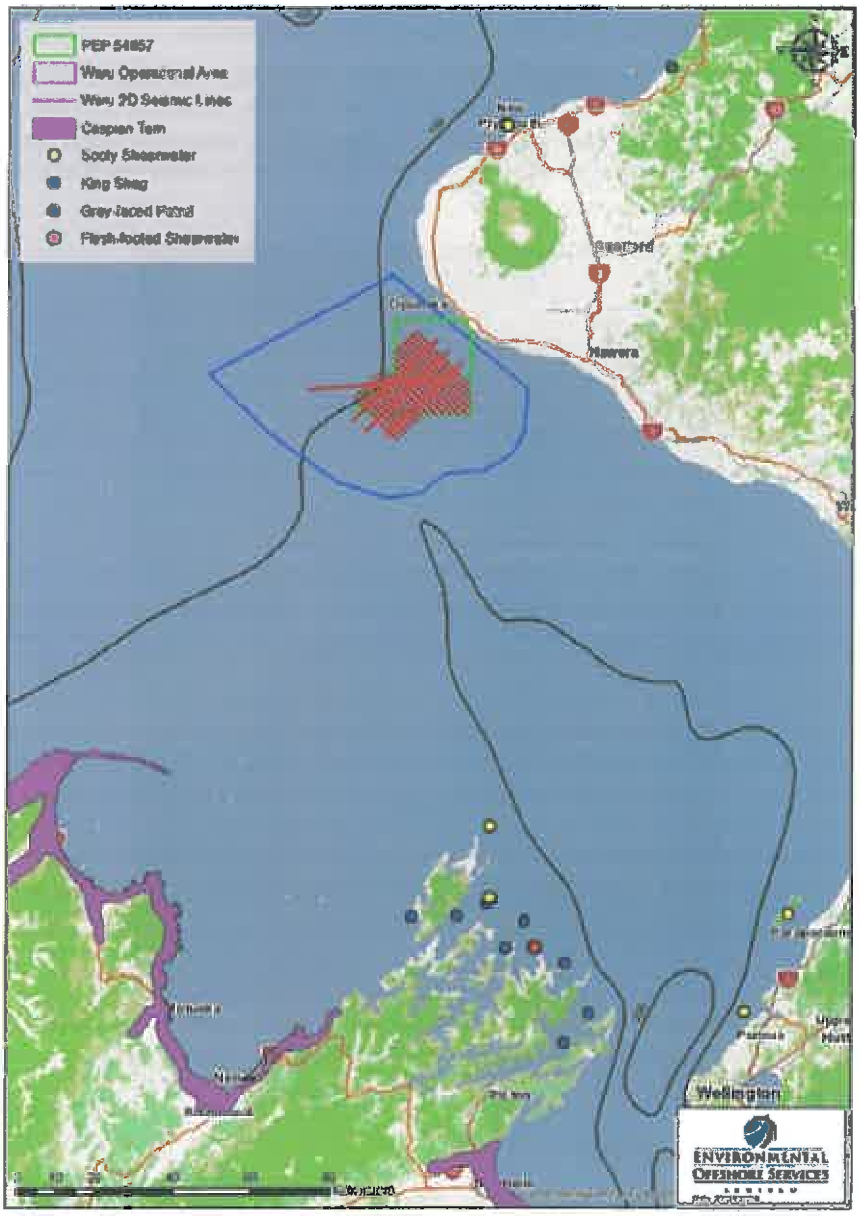

Figure 15: Breeding colonies of seabirds surrounding the Waru Operational Area

4.2.10 Deep Sea Corals

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). Corals can live for up to hundreds of years and exist either as individuals or colonies.

The potential effects of acoustic noise on corals is not well publicised due to a lack of literature. It has been suggested that sound emission from an acoustic source could either remove or damage polyps on the coral calcium carbonate skeleton but has not been reported so far. A 3D MSS was undertaken around Scott Reef in Western Australia in 2007 by Woodside Energy Ltd and a pre- and post-seismic survey field experiment was conducted at the same time. Results did not show any detectable effects of acoustic source noise emissions on any coral species (Woodside, 2007).

Black coral is protected within NZ's EEZ under the Wildlife Act, 1953 and is distributed off the west coast of the North Island, along the shelf break from Cape Egmont to northern NZ (Figure 16) (MPI, 2014b). The Waru Operational Area is located 115 km southeast of the southern distribution of black coral in the offshore Taranaki waters.

During the corals planktonic or pelagic phase of their lifecycle, mortality has been observed of the plankton if they are at close range (< 5 m) of the acoustic source (DIR, 2007). However, given the abundance of the planktonic populations and their high natural mortality rates from stochastic events, these effects on the plankton in close to the acoustic source would be considered negligible.

Figure 16: Black coral distribution around the Waru Operational Area

4.2.11 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. There are a number of PNA's surrounding the Waru Operational Area; the closest being Tapuae Marine Reserve (Figure 17).

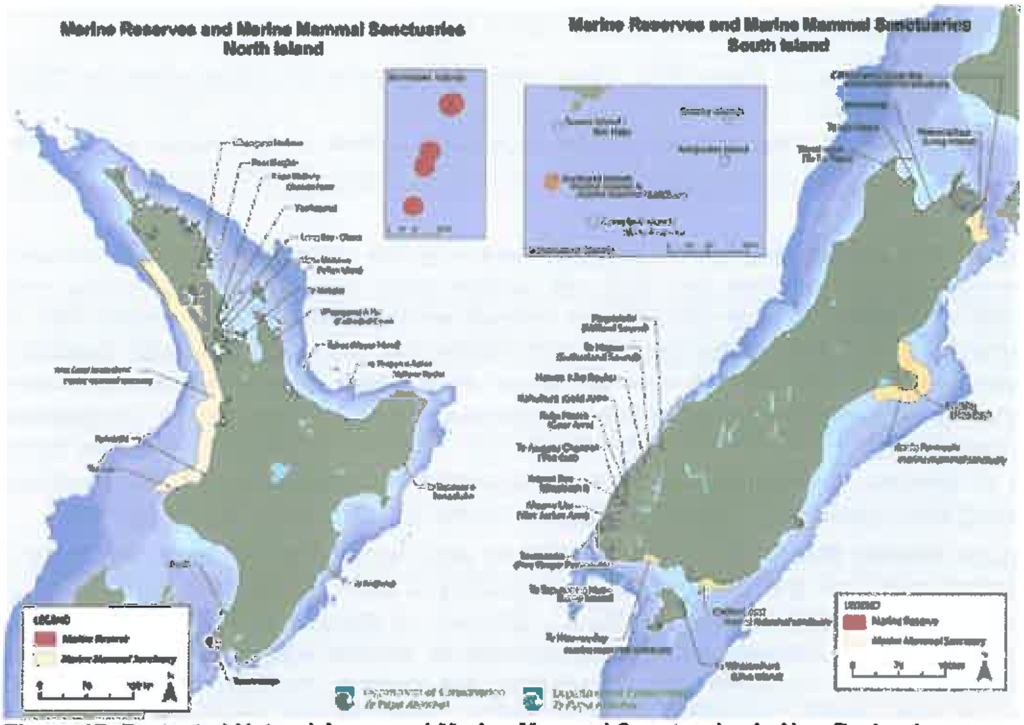

Figure 17: Protected Natural Areas and Marine Mammal Sanctuaries in New Zealand

4.2.12 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 km^2 of seabed was protected which equates to ~32% of the EEZ. The nearest BPA to the Waru Operational Area is on the Challenger North Plateau, 250 km to the west (Figure 18).

Figure 18: Benthic Protected Areas in relation to the Waru Operational Area

4.2.13 Taranaki Areas of Significant Conservation Value

The Taranaki Regional Coastal Plan (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 Waru Operational Area are shown in Figure 19 and discussed further below.

- **Sugar Loaf Islands Marine Protected Area** – 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, 2014e). 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;
- **Whenuakura Estuary** – a relatively unmodified estuary providing habitat for the threatened Caspian tern and rare variable oystercatcher. The estuary is a route for migratory birds and is an important whitebait spawning habitat;
- **North and South Traps** – an unusual feature on an otherwise sandy coastline with an extensive *Ecklonia radiata* kelp forest present which is diverse and abundant in marine life;
- **Waverley Beach** – is regarded as an outstanding natural landscape with eroding stacks, caverns, tunnels and blowholes;
- **Waitotara Estuary** – an unmodified estuary with a number of sub-fossil totara stumps present. It provides habitat to a number of threatened birds (Australian bittern, NZ shoveller and black swan) as well as being a stopover point for migratory wading birds and international migrant birds; and
- **Waiinu Reef** – has limestone rock outcrops which extend from shore out to 500 m offshore. Many well-preserved fossils are present in the hard rock platforms and there is an abundance of marine life around these outcrops and platforms.

Figure 19: Taranaki Areas of significant conservation value and DOC Area of Ecological Importance

4.3 Cultural Environment and Customary Fishing

Maori have a strong relationship with the sea and the collection of kaimoana is a fundamental part of their life, and for coastal hapu, kaimoana is often vital to sustain the mauri (life force) of tangata whenua. Collection of kaimoana allows Maori to provide a food source for whanau (family) and hospitality to manuhiri (guests).

The Taranaki coastline is home to a number of iwi and hapu, where the coastal marine area is culturally important for collecting kaimoana and protection of spiritual values (Figure 20).

There are a number of marine species which iwi value highly and include: snapper, kahawai, blue cod, flat fish, small sharks, grey mullet, sea urchin (kina), scallops, mussels, paua, pipi, toheroa, cockles and tuatua (MPI, 2014d).

Figure 20: Taranaki Iwi boundaries
(**Note**: Iwi boundaries may not be accurately representative of each particular Iwi)

Fishing and gathering of kaimoana along the Taranaki coastline is a fundamental part of being Maori and living along the Taranaki coast, where tangata whenua hold a very strong relationship with the sea. Traditional management entails a whole body of knowledge about the resources from the sea and how and when to access it. Customary knowledge is held sacred by tangata whenua and only passed on to those who will look after that knowledge.

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 (mataitai reserves) to oversee fishing within these areas and create management plans for their overall area of interest.

Mataitai comprise of traditional fishing grounds established for the purpose of recognising and providing kaimoana collection and customary management practices. Commercial fishers cannot fish within a Mataitai 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 customarily or significant to an iwi or hapu 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.

Within the Waru Operational Area there are two established customary areas under the Fisheries Act or Kaimoana Customary Fishing Regulations, Ngati Haumia and Titahi-Ngaruahine (Figure 21), both of which were gazetted regarding the important kaimoana reefs within this stretch of coastline, both intertidal and subtidal.

The rohe of Ngati Haumia extends from the Waiaua River to the Ouri Stream and by the course of those waterways to Mount Taranaki. Ngati Haumia are affiliated by whakapapa to the Taranaki iwi. Kaimoana is pivotal to the mana of Ngati Haumia, particularly in respect of their ability to show manaakitanga (hospitality), support their Kaumatua, and help cater for functions such as tangi. The Ngati Haumia rohe moana was gazetted in 2011.

The Titahi-Ngaruahine rohe moana was gazetted in 2011 and is located between the Taungatara and Waihi Rivers. The rohe moana was put in place for protection of customary rights and customary marine title through recognition agreement with the Crown.

NZOG have engaged with Nga Ruahine and Taranaki Iwi Trust over the last few years as a result of previous MSS's or the NZP&M block offers, prior to any decision being made by NZP&M. A summary of the engagements in relation to the Waru MSS is provided in Appendix 2.

Taranaki iwi regard paua as taonga and it is highly valued as kaimoana. Paua 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 paua 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 paua resource; thereby affecting the ability to harvest paua for customary needs.

Following a Hui held at the Orimupiko Marae in Opunake, the significance of the longfin eels to Maori was raised; in particular the migration of the longfin eel and the return of the glass eel. The longfin eel is an important resource for Maori, 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 (Te Ara, 2014c).

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 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, 2014c).

The exact migration route of these longfin eels is still unknown but research is been undertaken by NIWA to identify their migration routes and destination utilising pop off tags. The Waru 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 Waru MSS and acoustic source. 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 4.2.2, 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 Waru 2D MSS (late March) it will not interfere with the return of the longfin eel larvae (July-December) and given the short duration of the Waru 2D MSS, the migrating adult longfin eels are unlikely to be influenced in any way.

Figure 21: Culturally important areas surrounding the Waru Operational Area
(**Note**: Rohe Moana boundaries may not be accurately representative of each particular hapu)

4.4 Anthropogenic Environment

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

4.4.1 Recreational Fishing

The Taranaki waters around the Waru Operational Area support significant recreational fisheries for snapper, kingfish, hapuku/bass, trevally, kahawai, tarakihi, gurnard and crayfish. During the summer months when sub-tropical waters bringing warm water to the south, billfish, tuna and other pelagic species visit Taranaki and the South Taranaki Bight. Taranaki waters are one of NZ's most significant big-game fisheries and is growing in popularity, although most gamefish are generally caught in north Taranaki waters.

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. The closest boat launching ramp to the Waru Operational Area is at Middleton's Bay, Opunake which provides access to the reef areas inshore and to the north of the Waru Operational Area.

4.4.2 Commercial Fishing

Ten Fisheries Management Areas (FMA) have been implemented within NZ waters to manage the Quota Management System (QMS) and is regulated by MPI (Figure 22). Over 1,000 fish species live in NZ waters (Te Ara, 2014d) of which the QMS provides for commercial utilisation of 96 species while ensuring sustainability (MPI, 2014e). These species are divided into separate stocks and each stock is managed independently to ensure the sustainable utilisation of that fishery.

Figure 22: Fisheries management areas within NZ waters

Within NZ the commercial fishing activities are monitored closely; 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 for the Waru Survey Area and has been used within this MMIA to provide a summary of commercial fishing activities and what species are targeted (Figure 23).

Figure 23: Trawl effort in the Waru Survey Area, South Taranaki Bight

The fisheries assessment was undertaken for the period 1 October 2008 to 30 September 2013 within the Waru 2D Survey Area which included all the fishing events that either started, ended or passed through the survey area shown in Figure 23. Over the last five years, trawling has been the dominant fishing method with small amounts of set netting also taking place. Trawling has accounted for 93% of the 321 fishing events during the assessment period.

From the fishing activity reported within the Waru 2D Survey Area, jack mackerel and gurnard are the most commonly targeted species, with jack mackerel being the species taken in the greatest quantity by a considerable margin. Of the 2,683 tonnes of fish caught within the Waru 2D Survey Area during the 2008/09 – 2012/13 fishing years, jack mackerel and barracouta accounted for 88% of the total landings (Table 7).

Table 7: Estimated catch within Waru Operational Area from all fishing events during 2008-2013 (tonnes)

Species	2008-09	2009-10	2010-11	2011-12	2012-13	Total
Jack mackerel	481	450	521	303	210	**1,966**
Barracouta	15	203	72	45	55	**390**
Trevally	8	21	13	7	5	**53**
Frostfish	3	13	8	13	12	**49**
Gurnard	10	9	10	10	4	**43**
Others	54	36	44	32	15	**182**
Total	**570**	**732**	**668**	**411**	**301**	**2,683**

Within the South Taranaki Bight the jack mackerel fishery is primarily conducted during December-January whereas the least amount of fishing occurs from February-August (Figure 24). The jack mackerel trawl fleet consists of 6 – 7 foreign charter vessels contracted to NZ operators and is likely to be responsible for the fishing activity within the offshore extent of the Waru Survey Area, who have all been advised of the Waru Operational Area and the potential commencement date of the Waru 2D MSS. However, smaller trawlers also operate closer to shore, where the vessels longer than 46 m in length are restricted to operate (Figure 23). These vessels have also been notified of the Waru 2D MSS and the anticipated commencement date.

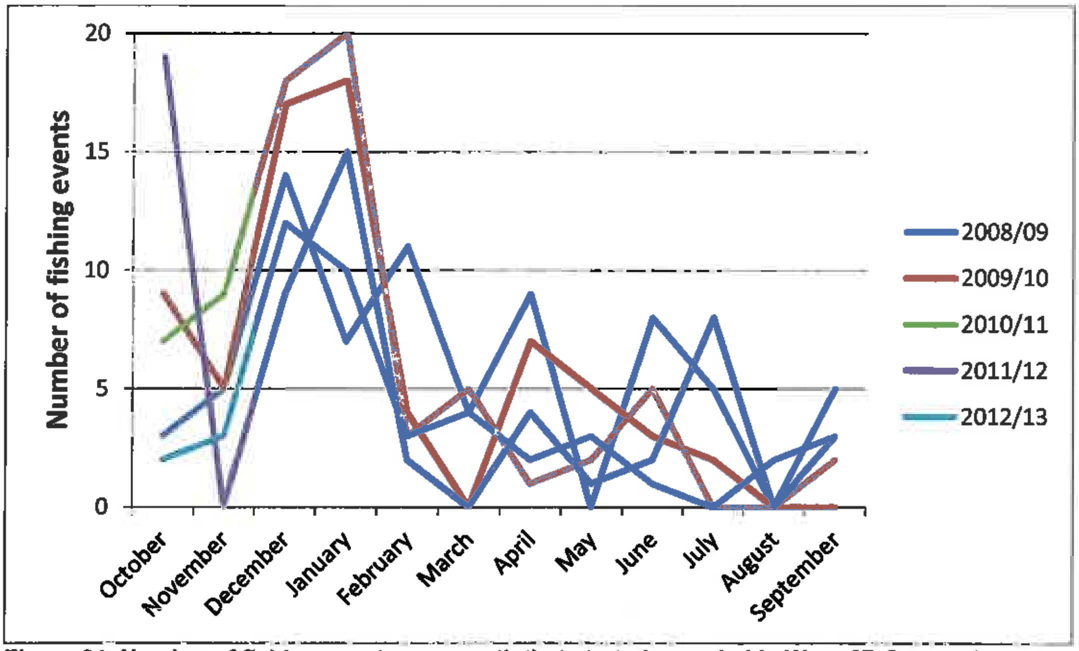

Figure 24: Number of fishing events per month that started or ended in Waru 2D Survey Area

Consultation has been undertaken with Egmont Seafoods, Deepwater Group, Sanfords, Independent Fisheries, Maruha (NZ) Ltd, Talley's, Sealord, Taranaki Commercial Fisherman's Associated, Challenger Finfisheries, Ocean Pearl fisheries, Fisheries Inshore New Zealand, Southern Inshore Fisheries Management Company Limited and NZ Federation of Commercial Fisherman to advise of the proposed Waru 2D MSS and the length of gear that will be towed behind the *Aquila Explorer*. These companies will be provided with the contact details of the vessel closer to the commencement date. A Notice to Mariners will be issued for the Waru 2D MSS and broadcast over maritime radio.

4.4.3 Shipping and Taranaki Precautionary Area

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 port to the Waru Operational Area is Port Taranaki which is the major servicing base to the petroleum industry in the South Taranaki Bight and has been since the beginning of the major Taranaki offshore and onshore oil exploration in the 1960s.

Commercial shipping vessels generally use the most direct path when travelling between ports; the general shipping routes between NZ ports surrounding the Waru Operational Area are shown in Figure 25. The Waru Operational Area is located within the general shipping route between Port Taranaki and the ports to the south. During consultation Port Taranaki has been advised of the proposed Waru 2D MSS and did not foresee any issues arising. Between Port Taranaki and any other NZ port 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 Waru 2D MSS commencing and will be broadcast daily on maritime radio. If all vessels adhere to the Notice to Mariners and the COLREGS there should be no conflict between shipping vessels and the *Aquila Explorer* over the five day Waru 2D MSS. The routes for foreign destinations from NZ ports is likely to vary, as they could either choose the most direct path or depending on weather conditions at the time, may transit closer to shore and these paths have not been included in Figure 25.

The International Maritime Organisation (IMO) established a precautionary area for Taranaki waters in 2007 which warns all ships travelling through this area that they must navigate with caution due to the high level of petroleum activity in the area. This precautionary area is a standing notice in the annual Notice to Mariners which are issued each year in the NZ Nautical Almanac. The navigational hazards within this precautionary area listed in the almanac include the Pohokura, Māui, Maari, Tui and Kupe fields.

On the maritime Chart NZ 48 – Western Approaches to Cook Strait, it states that 'All ships should navigate with particular caution in order to reduce the risk of marine pollution in the precautionary area'.

In 2000 IMO required for ships to be fitted with AIS as a primary collision avoidance tool. The *Aquila Explorer* has AIS technology on board and broadcasts at regular intervals key information (vessel position, identify, type, speed, course, etc.) and is received by all other vessels fitted with AIS, especially foreign going vessels moving between NZ ports.

Therefore, all vessels travelling through this area should be aware of the petroleum production and exploration activities and if they are following good practice, safety at sea and adhering to the COLREGS, any risk of collision should be avoided. The Waru Operational Area is bound by the Māui and Kupe fields and is located within the Taranaki precautionary Area (Figure 26).

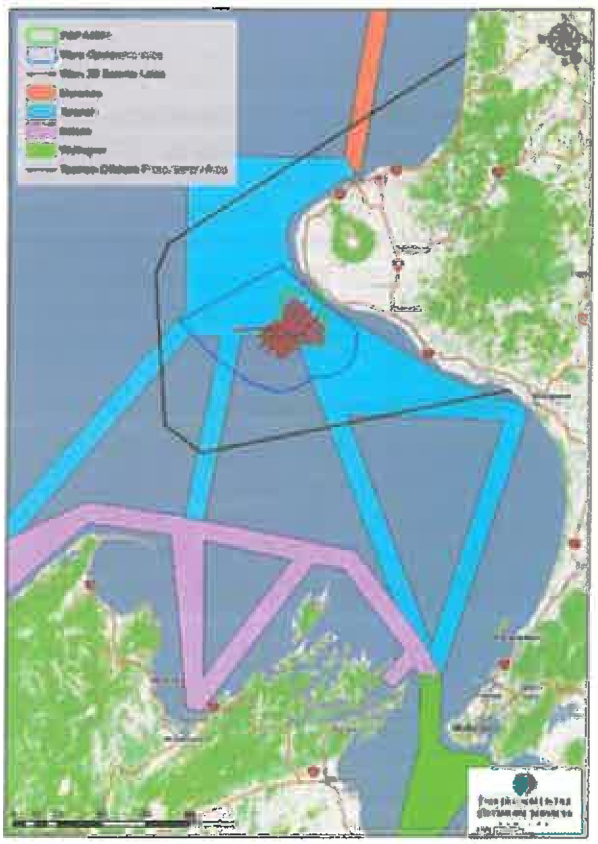

Figure 25: General shipping routes surrounding the Waru Operational Area

Figure 26: Taranaki Precautionary Area and offshore installations

4.4.4 Petroleum Exploration and Production

Exploration and production activities have occurred off the Taranaki coastline for more than 40 years and has increased in activity over the last ten years. Taranaki is NZ's hydrocarbon province and is the only region where oil and gas has currently been found in sufficient quantities to be economically viable. As a result Taranaki and the associated petrochemical industry is very important to NZ's economy.

Since the 1960's MSS's have been common off the Taranaki coastline with hundreds of thousands of kilometres acquired from both 2D and 3D MSS. The current extent of the Taranaki offshore oil and gas production operations in the Taranaki Basin is shown in Figure 27.

Figure 27: Taranaki producing oil and gas fields
(Source: http://www.teara.govt.nz/en/map/8934/taranaki-oil-and-gas-fields-2006)

5 Potential Environmental Effects and Mitigation Measures

This section presents a review of the potential environmental effects which may arise from the operation of the Waru 2D MSS programme in the marine environment, although they are specifically focused on effects to marine mammals. A literature review was undertaken in conjunction with EOS's knowledge of the environmental sensitivities within the South Taranaki Bight, to summarise the potential environmental effects which may result from the Waru 2D MSS, from both planned and unplanned activities. Mitigation measures that will be implemented for the Waru 2D MSS are also discussed for each activity.

The significance of each of these potential environmental effects was determined under the assumption that the proposed mitigation measures are in place. Four categories were determined for the scale of effects on marine mammals; however, this classification has also being applied indirectly to the wider marine environment and potential effects highlighted within this MMIA; ranging from negligible to major and are summarised below. This classification has been derived from the STLM due to the known SEL's at varying distances from the acoustic source and the thresholds for behavioural or injury criteria to marine mammals as defined within the Code of Conduct.

- **Negligible Effect** – marine mammals beyond 1.5 km from the acoustic source will be unaffected; based on the Code of Conduct mitigation zones for species of concern with calves present for a Level 1 MSS. No significant effects are expected within the marine environment or on other marine fauna. After exposure to the sound source, no recovery or mitigation measures are required;
- **Minor Effect** – Marine mammals between 1.5 km and 1.1 km from the acoustic source could be slightly influenced by sound levels, which is derived from the mitigation zones within the Code of Conduct and the STLM where 95% of SEL's are <171 dB re 1 $\mu Pa^2.s$ (SEL's are <171 dB re 1 $\mu Pa^2.s$ for most azimuths, it is due to the directionality of the array that some azimuths are >171 dB re 1 $\mu Pa^2.s$ – see Section 5.1.2.1). No noticeable effects observed within the marine environment or on other marine fauna. No mitigation measures are required to return to the original behaviour or environmental conditions;
- **Moderate Effect** – the behaviour of marine mammals is likely to be influenced between 1.1 km and 200 m from the acoustic source. This is based on the STLM results where >1.1 km from the acoustic source 95% of the SEL's are <171 dB re 1 $\mu Pa^2.s$ and >200 m from the acoustic source 100% of the SEL's are <186 dB re 1 $\mu Pa^2.s$. Behavioural effects to marine mammals are likely to occur and physical effects may develop closer to the source, but this is presumed to be temporary. Mitigation measures may be required; most likely operating to best practice for a return to the original environmental condition or behaviour; and
- **Major Effect** – environmental effect requires mitigation measures to be implemented, and once implemented the original situation takes a relatively long period of time to recover, in some cases not at all. For marine mammals this is likely to occur within 200 m of the acoustic source, based on the STLM. Modelling showed that the SEL is >186 dB re 1 $\mu Pa^2.s$ within 200 m of the source (Koessler & Duncan, 2014) which is the SEL believed to result in some form of injury to marine mammals as defined in the Code of Conduct. No recovery is anticipated from this type of environmental effect.

To accurately assess the potential environmental effects that could potentially result from a MSS, both the planned and unplanned activities have to be taken into account. The following sections assess these potential effects and what mitigation measures will be implemented for the Waru 2D MSS to keep environmental effects to ALARP.

5.1 Planned Activities – Potential Effects & Mitigation Measures

5.1.1 Physical presence of the *Aquila Explorer* and the Seismic Array

The *Aquila Explorer* and the associated seismic array towed behind the vessel, as well as the support vessel 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 for the Waru 2D MSS to interfere with fishing activities due to the 8 km streamer that will be towed behind the *Aquila Explorer*. During the Waru 2D MSS, fishing vessels (mainly commercial) will be caused a temporary loss or reduction of access to any fishing grounds within the Waru Operational Area; however, this would only occur for the duration of the Waru 2D MSS (~5 days). Commercial fishers who use the Waru Operational Area as part of their fishing grounds have been advised of the Waru 2D MSS and will be contacted closer to commencement with further details. To date the communications have been positive with the commercial fishing industry and no concerns were raised of the proposed Waru 2D MSS, especially given the approximate five day duration. The acquisition of the Waru 2D MSS could potentially cause temporary displacement of fish stocks; particularly pelagic species such as jack mackerel which is the most commonly targeted and caught species in these offshore Taranaki waters (Section 4.4.2).

Trawling is the most common method of commercial fishing in Taranaki waters with 93% of fishing events within the Waru 2D Seismic Area attributed to trawling. It is a mobile method of fishing, so no fishing gear is left deployed on the seabed which has the potential to cause conflict between the survey vessel and fishers if set nets were left deployed within the Waru Operational Area. As discussed in Section 3.1, a tail buoy will be on the end of the streamer to mark the overall extent of the streamer and to avoid any uncertainty as to how far the streamer extends behind the *Aquila Explorer*.

To ensure that the potential environmental effects are minimised to ALARP, NZOG will operate 24 hours a day (weather and marine mammal encounters permitting) to minimise the overall duration of survey; comply with the COLREGS (radio contact, day shapes, navigation lights etc.); have a support vessel present at all times; notify commercial fishers of the Waru 2D MSS and Waru Operational Area; issue a Notice to Mariners and have a tail buoy attached to the end of the streamer to mark its end.

With the mitigation measures in place, the relatively short survey duration (~5 days), the effects from the Waru 2D MSS on any fishing activities, commercial or private vessels is believed to be ***minor***.

5.1.1.2 Interference with Marine Archaeology, Cultural Heritage or Submarine Infrastructure

The seismic array used for the Waru MSS will not come into contact with the seabed or coastline inshore of the Waru Operational Area. The solid streamer used in the Waru MSS has self-recovery devices fitted which release once the streamer reaches a certain depth bringing the streamer back to the surface for retrieval should it be severed and start sinking. Most of the areas that are culturally significant are on the intertidal and shallow subtidal reefs located inshore of the Waru Operational Area. The Waru MSS has been designed so that the four survey lines which lie northeast-southwest will be acquired from offshore running inshore, and as soon as the vessel reaches the inshore extent of the survey line, the acoustic source will be stopped and the vessel will start turning. It would only be the result of a rupture to the vessels fuel tank that could cause any culturally or archaeological sites to be influenced, but with the mitigation measures in place as discussed through this MMIA, this should not occur. The Waru Survey Area is bound to the northwest by the Māui pipeline and to the southeast by the Kupe pipeline (Figure 26). These pipelines are on the seabed and covered in rock mattresses and boulders so there is no potential for any damage to occur from towing a single streamer just below the surface. The streamer has Self Recovery Devices (SRD) fitted which deploy for retrieval once the streamer sinks below a set depth so would ensure there is no interference with any sub-sea pipelines or infrastructure if it was severed in close proximity to this sub-sea infrastructure. Therefore it is considered that the potential interference with any marine archaeology, cultural heritage or submarine infrastructure is ***negligible***.

5.1.1.3 Changes in Abundance or Behaviour of Fish

It has been reported that MSS acquisition can temporarily alter the behavioural patterns of certain fish species; often causing them to dive deep and away from the acoustic source or tightening up in their school structure (McCauley *et al.*, 2000). Anecdotally it is believed that pelagic fish such as tuna are harder to catch off the Taranaki coastline based on fishers experience when previous MSS have been undertaken, however WesternGeco undertook a 3D MSS in January 2013 and 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 catch records from New Plymouth Sportfishing & Underwater Club below), with marlin even being hooked up in front of the operational 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).

Due to operations being carried out 24 hours a day, (weather and marine mammal encounters permitting) the Waru 2D MSS duration will be as short as possible (~5 days), and any potential effect on fish species within close proximity to the Waru Operational Area is considered to be ***minor***.

5.1.1.4 Changes in Seabird Behaviour

Seabirds can interact with vessels at sea; they can use vessels for perching opportunities that would not otherwise be available as well as negative interactions which could include injury to birds through collision or entanglement in the vessels rigging, particularly at night. Research has shown artificial lighting can cause disorientation in seabirds, although this is mainly for fledglings and novice flyers, particularly when vessels are operating close to shore (Telfer *et al.*, 1987). 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).

Seabirds have good eyesight and are agile flyers so the risk of any collisions during the day is unlikely compared to at night.

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 & 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.

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 & Davies, 1995), and once the acoustic source is operating, it is not likely that birds will be in the water close to the array.

Various aspects of the Waru 2D MSS will reduce the potential for any long term interference or damage to seabirds or reduce their ability to navigate and include: the short duration of the Waru 2D MSS (~5 days); the seismic and support vessels will always be underway and any diving birds in close proximity to the acoustic source are unlikely to do so due to their prey (baitfish) are likely to have fled the immediate area around the operating acoustic source. As a result the proposed Waru 2D MSS is considered to have ***negligible*** effects on seabirds.

5.1.1.5 Introduction of Marine Pest or Invasive Species

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

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 slipped in November 2013 where the hull was cleaned and new antifoul paint was applied. This dry-docking will have minimised the risk of any invasive species entering NZ waters on the *Aquila Explorer's* hull or seachests.

The support vessel *Amaltal Mariner* 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 Waru 2D MSS is ***negligible***.

5.1.1.6 Interaction of the Seismic Vessel **Aquila Explorer** *with Marine Mammals*

Within the Waru Operational Area, under the NZ threat classification list, three marine mammals classified as 'nationally critical' (Bryde's whale, killer whale and Maui's dolphin) and three as 'nationally endangered' (southern right whale, Hector's dolphin and bottlenose dolphin) could potentially be present during the Waru 2D MSS (Table 6). In NZ blue whales are currently classified as a 'migrant' under the NZ threat classification system as they are not known to breed here and therefore does not designate a threat status (Torres, 2013), however, this categorisation may change in the future once more research has found out more about these blue whales in the South Taranaki Bight. Blue whales have the potential to be in the Waru Operational Area, although most likely in the outer part where deeper water is present. Under the IUCN red list classification blue whales are listed as 'endangered' and are also listed as a Species of Concern in the Code of Conduct.

The potential to disrupt the behaviour of an individual or group of marine mammals would be a result of an interaction or collision with a vessel involved in the Waru 2D MSS or entanglement with the seismic array. Studies from a total of 292 records of confirmed or possible ship strikes to large whales have shown that 11 marine mammal species were confirmed as victims (Jensen & Silber, 2003); seven of which have been identified that could occur within the Waru Operational Area (killer, minke, sei, southern right, sperm, humpback and blue whales). From the study, the most commonly reported species of marine mammal hit was the finback whales (75 strikes) and humpback whales (44 strikes).

Jensen & Silber (2003) showed that vessel-type plays a role in the likelihood of mortality from any vessel interaction. Of the 292 mammal strikes; in 134 cases the vessel type was known of which navy vessels and container/cargo ships/freighters were the most common. Seismic vessels (described as research) accounted for one of the 134 known vessel marine mammal strikes. During acquisition the *Aquila Explorer* will be travelling at <4.5 kts, well below the mean speed which has accounted for most of the ship strikes (18.6 kts).

The *Aquila Explorer's* operations will be operating in adherence to the Code of Conduct and will also have 4 suitably qualified MMO's onboard for the duration of the Waru 2D MSS (operating procedures and mitigation measures further detailed in Section 2.2.1 and Section 5.3). Therefore as a result of compliance with the Code of Conduct, general operating procedures in accordance with best practice and the mitigation measures implemented, it is assumed that the effects on marine mammals arising from the Waru 2D MSS would be ***minor***.

5.1.2 Acoustic Source Sound Emissions

Sound emissions associated with the Waru 2D MSS have the potential to disturb marine mammals and other fauna through a number of ways, however these disturbances will be reduced by operating to the Code of Conduct and mitigation measures implemented. The potential effects to marine mammals could include: physiological effects from exposure to sound; behavioural disturbance or displacement; deep diving mammals surfacing too quickly which can result in 'decompression sickness'; disruption to feeding, breeding or nursery activities; interference with the use of acoustic communication signals or indirect effects such as changes in abundance or behaviour of prey for marine mammals, seabirds and fish.

Low frequency sound sources produced in MSS's 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 *et al.*, 1994).

Sound waves decay exponentially and travel until they either come in contact with an object or are dissipated by normal decay of the signal. Low frequency sound attenuates slowly and is why it is generally used in MSS's; however most of the sound energy attenuates very close to the acoustic source.

When an acoustic source is activated, most of the emitted energy is low frequency (0.01 – 0.3 kHz), but pulses also contain higher frequency energy (0.5 – 1 kHz), although these higher frequencies are often weak (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 MSS's focus on these sound waves generated from the acoustic source.

There is the potential for MSS operations to have an adverse effect on marine mammals and 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 (DOC, 2013).

Most marine mammals are believed to stay away or avoid an operating acoustic source used in a MSS, as a means of reducing their exposure to the higher sound levels. However during soft starts or using mitigation guns some species of marine mammals (e.g. killer whales) have been attracted to the acoustic source and are not considered as being adversely affected from the sound emissions. During other MSS's in North Taranaki, whenever the seismic vessel approached the shallower waters, common dolphins were observed heading straight for the vessel to come and bow ride while the vessel was under acquisition and the acoustic source was firing.

Pinnipeds are often observed 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 is nearly complete that focusses on pinnipeds behaviour around an operating seismic vessel, as well as those seals that were observed to be in a known sleeping position, and whether they are woken by the approaching seismic vessel. The data used within this study has drawn on all of the MMO reports that have been completed 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 in early 2014.

5.1.2.1 Sound Transmission Loss Modelling

Curtin University conducted 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 Waru 2D MSS to assess for compliance with the mitigation zones in the Code of Conduct (Appendix 5).

The STLM was predicted for the proposed Waru 2D MSS acoustic source (2,360 in^3) and was based on a water depth of 40 m which is shallowest water depth found in the northeast corner of the Waru Operational Area. 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.

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 radiation from the acoustic source array. The horizontal beam pattern showed that the bulk of the high-frequency energy is radiated in the cross-line direction, which is generally the case for acoustic source arrays, particularly those consisting of a small number of subarrays. The directionality of received levels in the horizontal plane is due to the directionality of the acoustic source array, which produces its highest energy levels in the cross-line direction (azimuths of 90° and 270°), and is very pronounced for this particular source due to it consisting of only two subarrays (Figure 28). The standard mitigation zones within the Code of Conduct are shown in Figure 28 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.

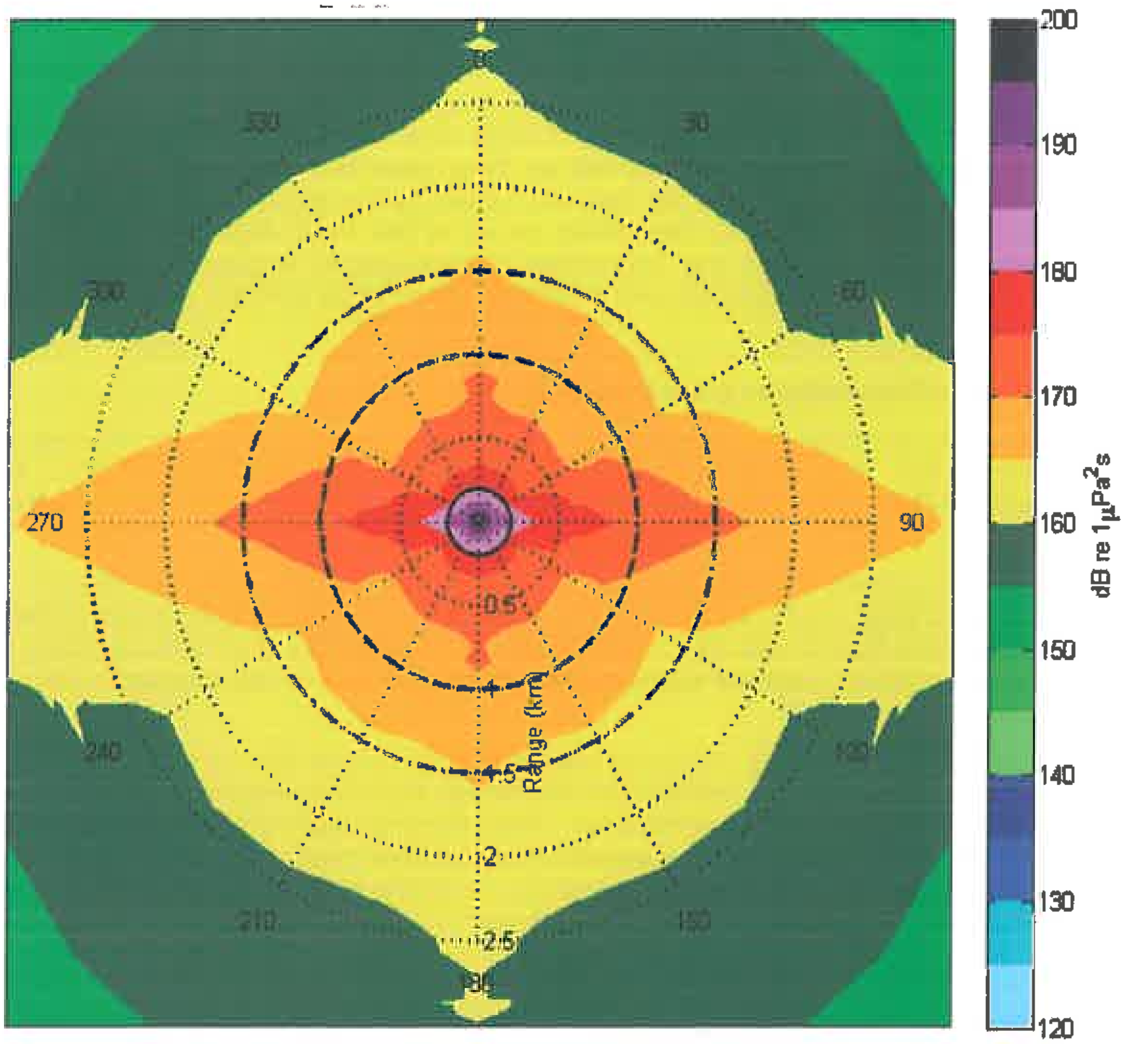

Figure 28: Maximum received SEL's at any depth from the acoustic source within the Waru Survey Area

The shallowest depth within the Waru 2D Survey Area (40 m) was utilised for the STLM as the highest short range received SEL's occur in shallow water due to the contribution of acoustic energy reflected from the seabed, therefore, lower received SEL's would be expected if the source was in deeper water than the 40 m modelled, i.e. the rest of the Waru 2D Survey Area (Koessler & Duncan, 2014). Due to the initial STLM results indicating that the modelled location had SEL's greater than 171 dB re 1 μPa².s at 1.0 km from the acoustic source, additional source modelling locations were completed at eight different bathymetric contours. This was undertaken to model various scenarios where the greatest SEL's would propagate and to determine results that can be applied to the adjustment of the mitigation zones.

The STLM indicated that 95% of receptions of sound were predicted to be below 186 dB re 1 μPa².s (injury criteria) at a range of just over 100 m while 100% of receptions were below 186 dB re 1 μPa².s within 200 m from the acoustic source.

SEL's were below 171 dB re 1 μPa².s (behaviour criteria) at a range of 1.0 km from the acoustic source for most azimuths, although some azimuths near the 90° azimuth (cross-line direction) were predicted to produce a SEL greater than 171 dB re 1 μPa².s (Koessler & Duncan, 2014). SEL's along all azimuths were below 171 dB re 1 μPa².s within 1.5 km from the acoustic source. This supports the 1.5 km mitigation zone for Species of Concern with calve present for a Level 1 MSS within the Code of Conduct. However, the SEL at 1.0 km from the acoustic source is greater than 171 dB re 1 µPa².s so as stipulated within the Code of Conduct the radius of the mitigation zone for Species of Concern needs to be extended.

To determine SEL's at various bathymetric contours through the Waru Operational Area a number of locations were modelled to see whether a staged approach could be applied to the mitigation zones or whether a single increase across the entire Waru Operational Area would be incorporated.

Water depths from 40 m down to 102 m were modelled to determine whether SEL's were below 171 dB re 1 µPa².s at 1.0 km anywhere within the Waru Operational Area. Due to the horizontal plane directionality of the acoustic array the maximum SEL's are expected in the cross-line direction, so this was modelled and the results are presented in a scatter plot as a function of range for the Waru 2D MSS acoustic source in different water depths (Figure 29).

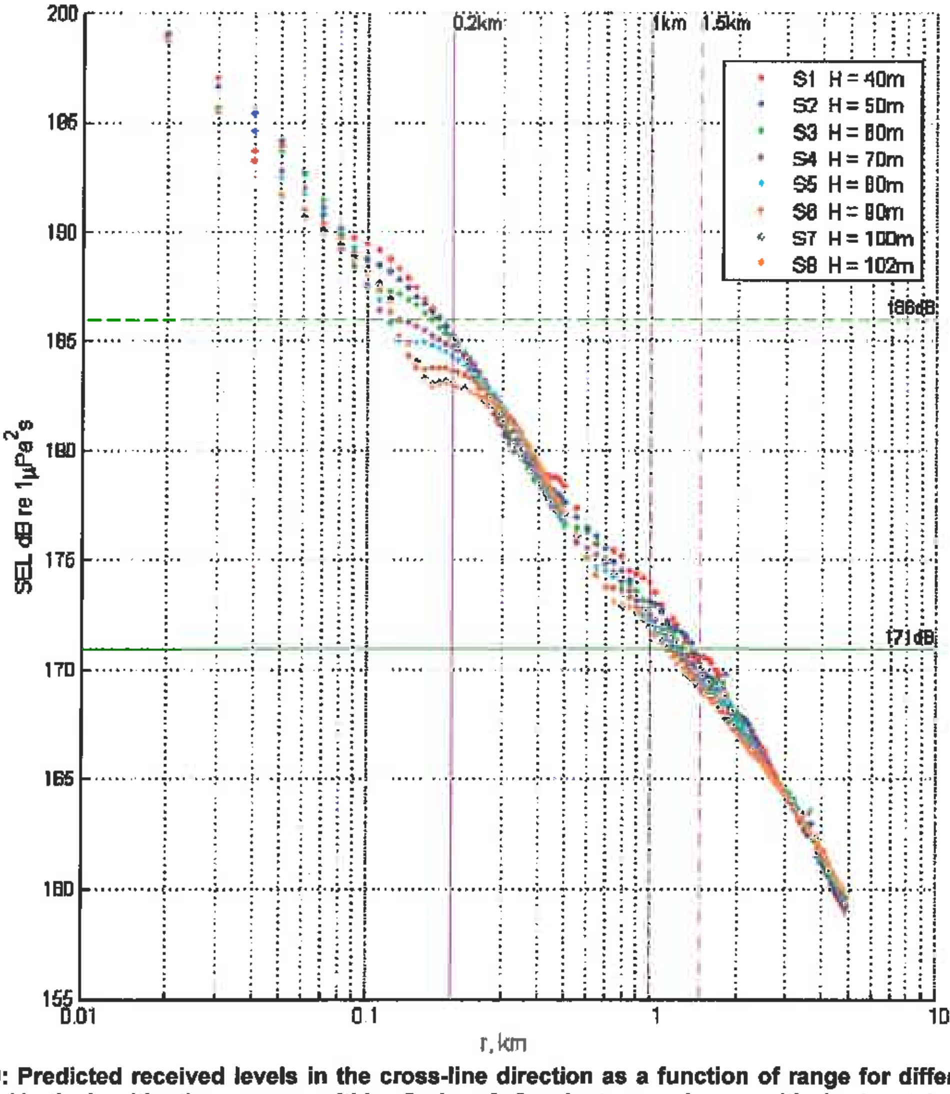

Figure 29: Predicted received levels in the cross-line direction as a function of range for different water depths. Vertical mitigation zones within Code of Conduct are shown with horizontal mitigation thresholds

As the water depth increases the SEL's decrease; however they do not drop below 171 dB re 1 µPa².s at 1.0 km for any water depth considered, of which the maximum depth was 102 m within the Waru Operational Area. At the maximum depth within the Waru Operational Area, the received SEL in the cross-line direction is predicted to be 172 dB re 1 µPa².s at 1.0 km and drops below 171 dB re 1 µPa².s at 1.15 km. Therefore a conservative approach has been taken following the STLM results and NZOG will increase the radius of the mitigation zone for Species of Concern (without calve) out to 1.5 km.

Bathymetry plays a part in the modelling results; upslope propagation into shallower waters results in more rapid attenuation and lower sound levels compared to the downslope propagation. 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.

As discussed in Section 4.1.4.2 the STLM incorporated a representative sound velocity profile for the summer months of the southern hemisphere to obtain the best estimate of environmental conditions for the commencement date of the Waru 2D MSS, of which included the presence of a thermocline. A sound velocity profile was used which clearly shows the presence of a thermocline and the reduction to the sound speed that results (Koessler & Duncan, 2014).

5.1.2.2 Physiological Effects on Marine Mammals and Fauna

Marine mammals can use sound actively or passively for foraging, navigation, communication, social behaviour, reproduction, parental care, avoidance of predators and overall awareness of the environment (Thomas *et al.*, 1992; Johnson *et al.*, 2009).

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). 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 is likely to be at a range of less than 200 m from the acoustic source.

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. There is a lack of conclusive data on the physiological effects of acoustic sound on marine mammals; as marine mammals are a protected species so they cannot be sacrificed for physical examinations and the physical size of most marine mammals does not generally allow captive studies to occur. It is generally considered unlikely that marine mammals would remain for any length of time close to any noise source that causes discomfort (Richardson *et al.*, 1995) assuming the initial noise levels received did not cause injury that prevented such movement, hence the pre-observations and soft start requirements within the Code of Conduct.

In adherence to the Code of Conduct; pre-observations and soft start procedures will help minimise any potential risk to marine mammals to as far as practicably possible prior to commencing the Waru 2D MSS. Likewise, if a marine mammal approaches the seismic vessel or acoustic source and enters the relevant mitigation zone; the trained and qualified MMO's onboard the *Aquila Explorer* have the authority to shut down the acoustic source in accordance to the Code of Conduct.

A study was undertaken on the changes in occurrence of harbour porpoises across a 2,000 km^2 survey area during a commercial 2D MSS in the North Sea (Thompson *et al.*, 2013). Passive acoustic monitoring and digital aerial surveys were used to assess the response of the harbour porpoises from a 470 in^3 acoustic source array over ranges of 5 – 10 km, at received peak-to-peak sound pressure levels of 165–175 dB re 1 µPa and SEL's of 145–151 dB re 1µPa. It was shown that animals were typically detected again at affected sites within a few hours, and the level of response declined throughout the 10 day survey period. The number of acoustic detections within the survey area decreased significantly during the MSS period in the impact area compared to the control area, but this effect was small in relation to natural variation (Thompson *et al.*, 2013). It was concluded from the Thompson *et al.* (2013) study that prolonged seismic survey noise did not lead to broader-scale displacement into suboptimal or higher-risk habitats, and suggested that impact assessments should focus on sub-lethal effects resulting from changes in foraging performance of animals within affected sites.

For the South Taranaki Bight, the water column and benthic substrate characteristics are very similar with no particular areas identified for concentrating marine mammals other than the upwelling eddies that propagate north from the Kahurangi Shoals. The upwelling events are at the mercy of the weather, where weather conditions can either break up large aggregations of euphausiids or prevent the upwelling from occurring. If blue whales are in close proximity to the Waru 2D Survey Area feeding on euphausiids the Code of Conduct will be followed at all times to ensure that any effects from acoustic noise are ALARP utilising the mitigation zones which have been validated by STLM (Koessler & Duncan, 2014). From previous studies on blue whales during social and feeding encounters it was found that the blue whales increased their calls while a MSS is operational to increase the probability that the communications signals are heard (Di Iorio & Clark, 2009). However, the exact impact on blue whale behaviour and whether the blue whales would leave a feeding area with an operational MSS nearby is currently unknown. During the Waru 2D MSS, the MMO's onboard the *Aquila Explorer* will be following the Code of Conduct and this MMIA to ensure that the active acoustic source will not be any closer than 1.5 km to any Species of Concern at all times.

For marine fauna which cannot flee from an approaching seismic vessel and acoustic source (i.e. plankton, fish eggs and some sessile organisms) they could be at risk of physiological effects from sound exposure, however this appears to only occur at very close distances from the acoustic source.

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, which for a MSS is within a few tens of metres from the acoustic source (OGP/IAGC, 2004). The Waru 2D MSS will be operating in accordance with the Code of Conduct, to minimise the risks to marine mammals as far as practicably possible.

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 Waru 2D MSS is between 2 – 250 Hz, and the sound emissions will only occur every 8 – 9 seconds during acquisition. Another study on northern pike (*Esox lucius*), broad whitefish (*Coregonus nasus*) and lake chub (*Couesius plumbeus*) exposed to a 730 in^3 acoustic source (although significantly smaller than the Waru 2D MSS acoustic source – 2,360 in^3) found varying degrees of threshold shift, but recovery occurred within 24 hours of exposure (Popper *et al.*, 2005). For the Waru 2D MSS there is the potential that the acoustic source could induce temporary effects on fish species that are in close proximity to the acoustic source, but any lasting physiological effects of the Waru 2D MSS on fish species would likely be ***negligible***.

Larval stages of fish and invertebrates generally live in the surface waters where they have a pelagic lifecycle in their early developmental stages, feeding on phytoplankton and zooplankton. It is at this stage in their life cycle that they could be exposed to acoustic 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 acoustic 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. It appears that the Aguilar de Soto *et al.* (2013) study is the first evidence that continual sound exposure can cause growth abnormalities in larvae. It was concluded in the study that the small size of the scallop larvae and the absence of strong tissue density gradients in early developmental phases 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 µPa at 1m, but the particle velocities experienced by the larvae imply far-field pressure levels of 195-200 dB re 1 µPa. The report further concluded that given the strong disruption of larval development, weaker but still significant effects could be expected at lower exposure levels and shorter exposure durations. From the STLM, a SEL of 195-200 dB re 1 µPa is confined within 200 m of the acoustic array.

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 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; the Waru 2D Survey Area is located 8 km offshore from the Taranaki coastline, 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 study at 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 Waru 2D MSS will not be anything in comparison to 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 effects on fish and shellfish larvae is believed to be ***minor - moderate*** if they are in close proximity to the acoustic source.

There is currently little information on how marine organisms process and analyse sound, making assessments about the impacts of artificial sound sources in the marine environment difficult (Andre *et al.*, 2011). Research has shown that effects of acoustic noise produced from a MSS on macroinvertebrates (scallop, sea urchin, mussels, periwinkles, crustaceans, shrimp, gastropods and squid) results 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 (Koessler & Duncan, 2014). The effects that have been observed generally occur in shallow water, and given the depth of the Waru Operational Area (>50 m) the effects on benthic invertebrates is believed to be ***minor***.

Of the three main forms of marine macrofauna (mammals, fish and invertebrates), cephalopods belong to the last group, which is also the least understood and the study on the effects of marine noise on invertebrate species is extremely limited. Situated in the food chain between fish and marine mammals, they are also key bio-indicators for ecosystem balance in vast and complex marine ecosystems (Andre *et al.*, 2011). Although startle responses have been observed in caged cephalopods exposed to an acoustic source (McCauley *et al.*, 2000), studies addressing noise-induced morphological changes in these species have been limited (Andre *et al.*, 2011). However, 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 ± 5 dB re 1 µPa, with peak levels at 175 dB re 1 µPa. It was therefore concluded that the effects of low frequency acoustic noise for a long period of time could induce severe acoustic trauma to cephalopods (Andre *et al.*, 2011). Based on the STLM, the peak sound levels of 175 dB re 1 µPa would be observed within 800 m from the Waru 2D MSS acoustic source (Figure 28).

Squid and octopus are cephalopods and can be found in Taranaki waters; however squid mainly during the summer months. Squid are a pelagic species that form an important part of the marine food chain, with majority of the commercial squid fishing throughout NZ taking place during the months from January through to May (MPI, 2014f). However, most of the commercially caught squid within NZ waters is caught off the South Island and Auckland Islands. Squid are very short lived but are a fast growing species, only living for one year with spawning occurring between May and July (MPI, 2014g). Squid are caught in the Taranaki region during late summer when the warmer water is present (Section 4.1.4.2). The Waru 2D MSS will be commencing in the middle of the squid fishing season throughout southern NZ, so it is possible that squid could be present within the Waru Operational Area, although not in commercial volumes, and if they were present and in close proximity (<500 m) to the operating acoustic source there is the potential for trauma to cephalopods that could have a ***moderate*** effect. However, the adaptations these species have in place to reflect their short life cycle, i.e. fast growth rates and high fecundity levels, there is not anticipated to be any overall significant effects on any cephalopod populations in the South Taranaki Bight.

In Moriyasu *et al.* (2004) a summary of a literature review on the effects of acoustic noise on invertebrate species was undertaken. One study used a single acoustic source with source levels of 220-240 dB re 1 µPa 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 15 acoustic source sub array with a source level of 190 dB re 1 µPa at 1m 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 µPa) 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.

The mitigation measures and operational procedures in place for the duration of the Waru 2D MSS to minimise potential effects of acoustic noise on marine macrofauna include; the acoustic sound wave is directed downwards from the source; the observed avoidance behaviour of marine mammals and other mobile fauna while the acoustic sources are operating and adherence to the Code of Conduct. Most of the invertebrate and kaimoana species inshore of the Waru Operational Area will not be exposed to any significant sound waves, given sound attenuates rapidly going up into shallower bathymetry. As a result there is not believed to be any effect on any of the kaimoana species that local Maori gather along this important piece of Taranaki coastline.

5.1.2.3 Behavioural Effects on Marine Mammals and Fauna

In response to an operating MSS, behaviours of marine mammals and fauna can include fright, avoidance and changes in vocal behaviour (McCauley *et al.*, 1998; McCauley *et al.*, 2003). This has been observed in Mysticetes (baleen whales) as they operate at lower sound frequencies (moans at 10 – 25 Hz). Whereas Odontocetes (toothed whales and dolphins) are not likely to be detrimentally affected, as they operate at sound frequencies far higher than those generated by acoustic sources (> 5 kHz). The Waru 2D MSS will operate at a sound frequency of between 2 – 250 Hz.

Observations have shown that MSS's may cause some changes in localised movements and behaviours of cetaceans; generally swimming away from the acoustic source but in some instances rapid swimming at the surface and breaching (McCauley *et al.*, 1998; McCauley *et al.*, 2003). Although acoustic noise from a MSS does not appear to cause any changes to the regional migration patterns of cetaceans (McCauley *et al.*, 2003).

If the acoustic source from the Waru 2D MSS resulted in blue whales moving away from areas they were feeding in, it could potentially reduce their ability to capture large aggregations of krill. However, there have not been enough studies undertaken on how close an operating acoustic source would have to be to move a feeding blue whale from its food source to accurately assess this potential. The SEL stated in the Code of Conduct that effects the behaviour of marine mammals is 171 dB re 1 µPa, and from the STLM this was found to be within 1,150 m from the acoustic source. The mitigation zone for Species of Concern has been increased to 1.5 km, and as a result no feeding blue whales will be exposed to this SEL, given the MMO's will ensure operations are conducted in accordance with the Code of Conduct and this MMIA.

It has been observed that humpback whales exposed to seismic surveys, consistently changed course and speed to avoid any close encounters with an operating seismic array (McCauley, *et al.*, 2000). Sound levels for this avoidance response to occur were estimated at 160 – 170 dB re 1 µPa peak to peak. From the Waru 2D MSS STLM, these sound levels appear to be present within 2.5 km in front and behind the acoustic source (0° and 180°), while in the cross-line direction (90° and 270°) from the acoustic source this distance extends out to approximately 5.0 km (Figure 28).

A study on pink snapper held in captivity and exposed to an acoustic source demonstrated minor behavioural responses ranging from startle to alarm, suggesting that fish may actively avoid an active seismic source in the wild (McCauley *et al.*, 2003).

The Waru Operational Area is in moderate water depths (50 – 100 m) over a sloping sandy/muddy seabed and given the relatively short duration of the Waru 2D MSS (~5 days) and the likelihood that most pelagic fish or marine mammals would either avoid or move away from the acoustic source while it was operating, the Waru 2D MSS would likely have ***minor*** effects on marine mammals and fish behaviour.

5.1.2.4 Disruption to Feeding, Mating, Breeding or Nursery Activities

The potential effects to marine species identified in this MMIA that could be present in the Waru Operational Area include disturbance to feeding activities and displacement of habitat for the Waru 2D MSS duration (~5 days). Any species that were in close proximity to the acoustic source are likely to move away from the immediate area while the source is operational. Blue whales use the South Taranaki Bight as an important feeding area and it is discussed above in Section 5.1.2.3 what may result if blue whales are forced to leave any large aggregations of krill due to disturbance from a MSS. Thompson *et al.* (2013) indicated that prolonged seismic survey noise did not lead to broader-scale displacement into suboptimal or higher-risk habitats, and animals were typically detected again at affected sites where a MSS had been conducted within a few hours following the acoustic source being stopped, and the level of response declined throughout the 10 day survey period. However, there is anecdotal evidence from other MSS's conducted around NZ that there is the potential for NZ fur seals to be attracted to the survey vessel.

Once the seismic vessel and acoustic array has passed through an area, or once the Waru 2D MSS is complete, the sound source within the marine environment will have dissipated and there will be no further environmental effects on any species residing there. The number of survey lines and the line spacing of the Waru 2D MSS is completely different to a 3D MSS; for a 2D MSS there is less lines acquired and the line spacing is further apart (Section 3.1). Therefore, the potential disruption and disturbance to the marine organisms basic life histories, that are likely to be encountered within or adjacent to the Waru Operational Area is believed to be ***minor-moderate***, and although it is currently unknown moderate effect is if blue whales feeding on krill aggregations are disturbed in anyway.

5.1.2.5 Interference with Acoustic Communication Signals

Vocalisations from cetaceans, used for communication and navigation are the most studied and understood forms of acoustic communication in the marine environment. The ability to perceive biologically important sound is very important to marine mammals and any acoustic disturbance through human generated noise has the potential to interfere with their natural functions (Di Iorio & Clark, 2009).

If a MSS emits sound in the same frequency range as the sounds generated by cetaceans and interfered with or obscured signals in locations which are biologically significant to cetaceans, there is the potential for significant environmental effects (Richardson *et al.*, 1995).

The known frequencies of echolocation and communication calls for selected species of toothed whales and dolphins is summarised in Table 8. The known spectrum of echolocation signals are at much higher frequencies (6 – 130 kHz) than the high end of the operational range of MSS acoustic sources (<1 kHz). The greatest potential for interference of acoustic signals is at the highest end of the seismic spectrum and the lowest end of whales and dolphins communication spectrum.

Table 8: Cetaceans communication and echolocation frequencies

Species	Communication Frequency (kHz)	Echolocation Frequency (kHz)
Bottlenose dolphin	0.8 – 24	110 – 130
Common dolphin	0.2 – 16	23 – 67
Dusky dolphin	7 – 16	7 - 16
Killer whale	0.5 – 25	12 – 25
Long finned pilot whale	1 – 18	6 – 117
Sperm whale	0.1 – 30	2 – 30
Blue whale	0.01 – 0.04	0.01 – 0.4
Humpback whale	0.02 - 2	0.02 - 2
Bryde's whale	0.07 – 0.9	0.07 – 0.09

Toothed whales communication calls partially overlap with the high end of a seismic acoustic source operational range, the acoustic energy emitted from the acoustic source array for the Waru 2D MSS is between 0.02 – 0.25 kHz; well below the lower frequency limits of most toothed whales. Sperm whales, common dolphins, humpback, Bryde's and blue whales vocalise at a frequency (0.01 – 0.4 kHz) that could be influenced from the frequencies emitted during a MSS (Table 8).

Blue whales have been shown to increase their calls (emitted during social encounters and feeding) when a MSS using a low-medium power source is operational compared to non-exploration days (Di Iorio & Clark, 2009; Melcon *et al.*, 2012). A mean sound pressure used in this study was relatively low (131 dB re 1µPa (30 – 500 Hz) with a mean sound exposure level of 114 dB re 1µPa²s. It is at these SEL's that blue whales will change their calling behaviour in response to a low-medium acoustic source and was presumed to have a minor environmental effect (Duchesne *et al.*, 2007). The STLM for the Waru 2D MSS is confined to approximately 3 km from the acoustic source and does not show the SEL of 114 dB re 1µPa²s that results in blue whales changing their calling behaviour. However from the STLM it could be assumed that the area around the operating acoustic source where blue whales will change their calling behaviour could be quite extensive.

It is thought that the blue whale increases its calling to increase the probability that its signal will be successfully received by conspecifics. In the study by Di Iorio & Clark (2009) the survey area was crossed by a busy shipping lane and vessel noise was common. It was concluded that noise from shipping did not account for any changes in acoustic behaviour of the blue whales. From the available literature the effects of seismic surveys on blue whales are unknown, other than increasing their calling when an acoustic source is operating (Di Iorio & Clark 2009). NIWA completed a research voyage in January 2014 to study blue whales further in the South Taranaki Bight, of which the results will be very important to further increase the understanding of these marine mammals which have been frequently observed over the last few years of MSS's conducted in the South Taranaki Bight.

Humpback whales have also being shown to decrease their calling while an acoustic source was emitted from an Ocean Acoustic Waveguide Remote Sensing experiment. The occurrence of humpback whale songs were compared prior, during and after the experiment and again two years later and it was shown that vocalising cetaceans can be effected by anthropogenic sound (Risch *et al.*, 2012). However, due to the timing of the Waru 2D MSS, there is not expected to be any humpback whales present during the survey scheduled for mid-March 2014.

From the reviewed studies and literature available it is believed that the Waru 2D MSS will have a ***minor-moderate*** effects on marine mammals use of naturally produced acoustic signals, and once the Waru 2D MSS is complete (~5 days) there will be no more influence or interference with any mammals communication or echolocation frequencies.

5.1.3 Solid and Liquid Wastes

During the Waru 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 Waru 2D MSS will include sewage and Greywater (wastewater from toilets, washrooms, the galley and laundry). The *Aquila Explorer* and *Amaltal Mariner* have onboard sewage treatment plants which ensures a high level of treatment before the sewage is discharged. All vessels involved in the Waru 2D MSS also 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 Waru 2D MSS receives, it is believed that only ***negligible*** effects on the marine environment would occur.

5.1.3.2 Generation of Galley Waste and Garbage

In accordance with the Resource Management (Marine Pollution) Regulations 1998 and 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 discharge 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 NZOG.

As a result of these operating procedures in place and adherence to MARPOL the environmental effects from galley waste and garbage on the marine environment is likely to be ***negligible***.

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 Resource Management (Marine Pollution) Regulations 1998 and MARPOL requirements of 15 ppm.

All vessels involved in the Waru 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 effects of any discharges to the marine environment would be ***negligible***.

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 short duration of the Waru 2D MSS (~5 days), the exposed nature of the Waru Operational Area and the anticipated low level of emissions, the environmental effects arising from the Waru 2D MSS is believed to be ***negligible***.

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 potential risk, no matter how low and this assessment has covered the potential of this occurring.

5.2.1 Streamer Break or Loss

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

The streamer to be used in the Waru 2D MSS is a solid streamer so if it were to break or be severed there is little potential for an environmental effect on the marine environment. The solid streamer is negatively buoyant and requires movement to maintain depth so if the streamer was severed it would start sinking. The streamer has SRD's which will deploy for retrieval once the streamer sinks below a set depth. This will prevent any potential for crushing of the benthic communities.

The Waru 2D MSS will be undertaken by experienced personnel using international best practice and as a result of the streamer type to be used for the Waru 2D MSS, if the streamer was severed or lost the environmental effect would be ***negligible***.

5.2.2 Fuel or Oil Spills

The potential for a fuel or oil spill during the Waru 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 from the *Aquila Explorer's* fuel tank did occur, the maximum possible spill if the fuel tanks were full would be 1,254 m^3 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, especially given that the hull of the *Aquila Explorer* is ice class rated. The high-tech navigational systems onboard, adherence to 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 Waru 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.

Therefore, due to the safety, environmental and maritime requirements that will be implemented for the Waru 2D MSS, the risk of a fuel or oil spill occurring is considered to be ***negligible***.

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, the issue of a Notice to Mariners advising of the *Aquila Explorer* being in the South Taranaki Bight undertaking the Waru 2D MSS and adherence to the COLREGS. As a result, the potential risk for a vessel collision or sinking is considered to be ***negligible***.

5.3 Mitigation Measures

NZOG will adhere to the mitigation measures identified in the Code of Conduct for operating a Level 1 MSS to minimise any adverse effects to marine mammals from the MSS operation (DOC, 2013). Due to the Waru Operational Area being within an AEI and as a measure of best operator practice, NZOG will implement additional mitigation measures, over and above the Code of Conduct. While undertaking the Waru 2D MSS, if there are any instances of non-compliance to the Code of Conduct and the mitigation measures identified below, the Director-General will be notified immediately.

The South Taranaki Bight has recently been identified as an area important to blue whales have been observed through MSS observations, general public and NIWA surveys. Importance will be given to these observations and any sightings will be distributed to the appropriate institutes to help increase the knowledge of the blue whales, classified as Species of Concern in the Code of Conduct. From the sightings recorded to date there is the potential that blue whales could be seen throughout the year in the South Taranaki Bight, so the MMO's will pay particular attention to the presence of any blue whales.

The operational procedures that NZOG will follow will be detailed in the MMMP (Appendix 4) 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 Waru 2D MSS the requisite mitigation measures specific to a Level 1 MSS are identified in Section 2.2.1. However, due to the Waru 2D MSS operating in an AEI and NZOG's desire to operate to best operator practice, additional mitigation measures are to be implemented. These additional measures are discussed in Section 5.3.2.

5.3.2 Additional Mitigation Measures for the Waru 2D MSS

5.3.2.1 Sound Transmission Loss Modelling

As discussed in Section 5.1.2.1 STLM has been undertaken to predict SEL's at various distances from the *Aquila Explorers* operating acoustic source; with the modelling based on the specific configuration of the acoustic source array to be used for the Waru 2D MSS and the environmental conditions present within the Waru Operational Area.

The Code of Conduct requires that any MSS undertaken in an AEI that the STLM has to provide the relative distances from the acoustic source which behavioural criteria (171 dB re 1μPa^2.s) and injury criteria (186 dB re 1μPa^2.s) could be expected.

The STLM showed that for the Waru 2D MSS, 95% of receptions of sound were predicted to be below 186 dB re 1 μPa^2.s (injury criteria) at a range of just over 100 m while 100% of receptions were below 186 dB re 1 μPa^2.s within 200 m from the acoustic source which is compliant with the Code of Conduct criteria. However, the received SEL was predicted to be 172 dB re 1 μPa^2.s at 1.0 km and is below 171 dB re 1 μPa^2.s at 1.15 km. As a result, NZOG have taken a conservative approach and increased the radius of the mitigation zone for Species of Concern (without calve) to 1.5 km. As a result adherence to the Code of Conduct for a Level 1 MSS and the amended mitigation zone for Species of Concern (without calve) following the STLM results, the potential risk of negative effects to marine mammals should be minimised to ALARP.

As per the requirements in Appendix 1 of the Code of Conduct, the STLM will be validated during the Waru 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.

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, sound exposure levels (dB re 1μPa) will be recorded by receivers in the streamer located at three different offsets from the acoustic source; 200 m, 1.0 km and 1.5 km. Even though the mitigation zone for Species of Concern within the Code of Conduct was increased from 1.0 km to 1.5 km following the results from the STLM, this offset distance from the source will still be validated to see how the modelling results compared. These recordings will take place within the Waru Operational Area across different depth measurements, with SEL's measured at varying water depths, as sound exposure levels 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.

5.3.2.2 Any Maui's Dolphin sightings will be notified immediately

If a Maui's dolphin is observed at any stage during the Waru 2D MSS or while the *Aquila Explorer* is mobilising to and from the Waru Operational Area, DOC National Office (Ian Angus) and DOC Taranaki Area Office (Callum Lilley &/or Bryan Williams) will be notified immediately.

DOC are keen to help with further research of this endangered species and if a sighting was to occur, depending on the location DOC may mobilise either a fixed wing plane for verification and/or a vessel to try and obtain a biopsy sample.

5.3.2.3 Additional marine mammal observations outside the Waru Operational Area

The *Aquila Explorer* will travel to the Waru Operational Area from its previous seismic survey. On transit to the Waru 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.

Any marine mammal observations outside the Waru Operational Area will be recorded in the 'Off Survey' forms developed by DOC. Any Maui's dolphins observed will be reported immediately to DOC as per Section 5.3.2.2.

5.3.2.4 Autopsy will be undertaken on any stranded marine mammals

If any marine mammals are stranded or washed ashore during the Waru 2D MSS inshore of the Waru Operational Area from New Plymouth south to the Kapiti coastline, NZOG 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 NZOG will cover the associated costs. NZOG will meet these costs for any necropsies required during the Waru 2D MSS and for a period of two weeks after MSS completion.

5.4 Cumulative Effects

The Taranaki Basin and South Taranaki Bight is currently used for shipping, fishing and hydrocarbon exploration and production activities. Studies on blue whales, where the survey area was overlapped by a busy shipping lane concluded that shipping noise did not account for any changes in the acoustic behaviour of blue whales (Di Iorio & Clark, 2009); hence noise from shipping traffic has not been considered in this cumulative effects assessment.

At the time of preparation of this MMIA and through consultation with DOC National Office, there is the potential that a check-shot survey could be undertaken from the Kan Tan IV (discussed below) and possibly a site survey which is also scheduled for some time in March 2014. The site survey will only be for a short duration and will utilise a small acoustic source volume (<150 in^3) so is therefore not subject to the Code of Conduct. As a result the cumulative effects from two concurrent MSS operating has not be considered as part of this assessment. For quality of the seismic data, the operators do not also want MSS's to overlap that are in close proximity to each other, as this has potential implications for the survey results acquired.

Check-shot surveys are significantly different to a vessel based 2D or 3D MSS; the acoustic source is limited to a single location and the shots are spaced over a relatively short duration (approximately four hours). Check-shot surveys are a form of borehole seismic survey and are used to correlate sub-surface seismic data from previous 3D MSS and the actual depth to geological intervals determined from drilling the well. The check-shot surveys utilise a small source volume (2 x 150 in^3) and fire approximately 150 shots at an operating capacity of 1,800 psi. In comparison to a 2D or 3D MSS, if the acoustic source for a check-shot was fired at the same rate (~8-10 seconds), the check-shot survey would be completed in 25 minutes. The Kan Tan IV is operating the check-shot surveys to a Level 2 survey under the Code of Conduct and will have trained and qualified MMO's onboard for the check-shot survey duration. The check-shot surveys are undertaken after each well is drilled, generally at the end of a 40 – 60 day drilling programme; and given delays that can occur within the drilling programmes it is unsure whether any check-shot surveys will coincide with the Waru 2D MSS. As a result it is believed the activity of check-shot surveys will provide a low risk to marine mammals, and likewise any cumulative effects of the check-shot survey and the Waru 2D MSS occurring simultaneously, would be ***negligible*** or ***minor***.

Underwater noise is generated from fixed production platforms and semi-submersible drilling rigs, both of which are currently present within the South Taranaki Bight. It has been suggested that underwater noise from platforms engaged in drilling do not exhibit markedly different characteristics from those engaged in production (Gales, 1982). However, McCauley (1998) indicated that underwater noise generated during drilling is roughly 10 dB higher than during production as a result of the natural frequencies in the drill string or the cutting action at the seafloor. It has also been shown from noise assessments around drilling and production platforms that noise from vessels associated with the platforms dominates the composite underwater noise signatures (Spence *et al.*, 2007).

From the Gales (1982) study on platforms engaged in drilling and production activities, no measured noise could be directly related to the mechanical action of the drill bits, and it was believed that most of the noise generated within the water column was created by the platform itself. These noise sources include power generation equipment, mud pumps, water and gas injection pumps, compressors and other large machinery items (Gales, 1982).

Greene (1986) found that broad band sound pressure levels (80 - 4,000 Hz) from a semi-submersible drilling rig in the Bering Sea measured at 0.1 m was 117 dB rel 1μPa with majority of the energy occurring below 2,000 Hz. Most of the sound emanating from the drilling rig became indistinguishable from ambient noise within the ocean at a distance of 0.5 Nm (Greene, 1986). Recorded playbacks of the sound emanating from the drilling rig was exposed to four captive Belukha whales for a period following a 30 day baseline observation period. Blood hormone levels were monitored as indicators of stress. Following noise exposure the beluga whales first showed a startle response but otherwise behaved as they had during the baseline period and no changes to hormone levels were found following exposure to the noise.

In conclusion the study indicated that the underwater sounds produced by a semi-submersible drilling rig did not significantly affect Belukha whales or, by extrapolation, other toothed cetaceans. The marine environment is very noisy and the animals that live there are most likely adapted to these conditions (Greene, 1986).

The closest drilling operation during the Waru 2D MSS is located within PMP 38158, approximately 40 km to the northeast from the closest proposed survey line within the Waru Operational Area.

However, given the short duration of the Waru 2D MSS (~5 days) and the distance between the platforms and the Waru 2D MSS compared to what the Greene (1986) study found background levels to be reached (~1 km), the cumulative effects on marine mammals is believed to be ***negligible*** or ***minor***.

There is the potential that during a MSS, if animals avoid an area due to the increased sound exposure; these species could result in additional exposure to predators as well as the loss of foraging or mating opportunities. However, once the Waru 2D MSS is complete, any resonant noise within the Waru Operational Area or surrounding marine environment would diminish. Following this the potential effects from increased sound exposure to marine mammals and fauna would cease and the animals could return to their preferred habitat. This was shown in the study by Thompson *et al*. (2013) where harbour porpoises returned to a seismic survey area within a few hours after the acoustic source had stopped and was concluded that seismic survey noise did not lead to broader-scale displacement into suboptimal or higher-risk habitats.

It is noted that following the completion of the Waru 2D MSS, the *Aquila Explorer* is contracted to undertake the Mohua 2D MSS for OMV within PEP 53537, approximately 50 km offshore from the Waru Operational Area. The same acoustic source will be used for the Mohua 2D MSS as the Waru 2D MSS and any sound attenuation out of the Waru Operational Area is not anticipated to influence any marine mammals that may be in the Mohua Operational Area.

The requirements and mitigation measures for a Level 1 MSS will be adhered to for the Waru 2D MSS; the *Aquila Explorer* will use the minimum acoustic source required to achieve the objectives of the Waru 2D MSS, essentially reducing the exposure risk to marine mammals and will either shut down or delay starts if any marine mammals are within the relevant mitigation zones.

Therefore, given it is likely that only the Waru 2D MSS will be operating in the South Taranaki Bight in the middle of March 2014 (given OMV's Mohua 2D MSS will occur after the Waru 2D MSS), the short duration of the Waru 2D MSS (~5 days) and the mitigation measures in place; the potential cumulative effects on marine mammals, marine fauna or the marine environment from the Waru 2D MSS will be ***minor***.

5.5 Summary of Environmental Effects and Mitigation Measures

The potential environmental effects and associated mitigation measures that will be implemented for the Waru 2D MSS as identified in this MMIA are summarised in Table 9.

Table 9: Waru 2D MSS planned and unplanned activities and the potential effects and mitigation measures to be implemented

Aspect or Source	Potential Environmental Effect	Likelihood of Occurrence or Exposure	Proposed Mitigation Measures	Residual Effect
Planned Activities				
Physical presence of the *Aquila Explorer* and the seismic array.	Interference with the fishing community and marine traffic.	Very low with mitigation measures in place.	24/7 operations to minimise overall duration of MSS (~5 days). Compliance with COLREGS, support vessel present at all times and notice to mariners issued.	Minor.
	Interference with marine archaeology, cultural heritage or submarine infrastructure.	Extremely unlikely given distance offshore and the streamer will not come in contact with the seabed.	Best Practice. Solid streamer with SRD.	Negligible.
	Changes in abundance or behaviour of fish.	Low.	24/7 operations (weather & cetacean observations permitting) to minimise overall duration of MSS.	Minor.
	Changes in seabird behaviour.	Likely - vessels may provide resting opportunities. Collisions or entanglements are unlikely during daylight, but could occur at night.	No mitigation options available. MMOs will record any seabird strikes that are witnessed.	Negligible.
	Introduction of marine pests or invasive species.	Low.	Recent dry-dock of the *Aquila Explorer* (November 2013) and new antifouling paint. Adherence to ballast water and hull fouling regulations.	Negligible.
	Interaction with marine mammals.	Low.	Compliance with the Code of Conduct and mitigation zones. Two MMOs and two PAM operators will be observing for mammals 24 hours/day.	Minor.
Acoustic Source Sound Emissions.	Physiological effects on marine mammals and fauna.	Low due to mitigation measures in place.	**Compliance with Code of Conduct.** **Four trained MMO/PAM operators with use of PAM 24/7.** **Pre-start observations, soft start and delay start/shut down procedures.** **STLM showed that 100% of receptions were predicted to be below the SEL for injury criteria at a range beyond 200 m, and below the SEL for behaviour change at a range beyond 1,150 m from the acoustic source.**	Minor-moderate.
	Behavioural effects on marine mammals and fauna.	Low.		Minor-moderate.
	Disruption to feeding, mating, breeding or nursery activities.	Low.		Minor-moderate.
	Interference with acoustic communication signals.	Low.		Minor-moderate.
Solid and liquid wastes.	Generation of sewage and greywater.	Will occur.	Only biodegradable waste will be discharged and will dilute to non-detectable levels. On-board sewage treatment plant, adherence to MARPOL, Resource Management (Marine Pollution) Regulations 1998 and approved ISPPC.	Negligible.
	Generation of galley waste and garbage.	Will occur.	Waste management plan where only biodegradable and comminuted waste will be discharged. Adherence to MARPOL and Resource Management (Marine Pollution) Regulations 1998.	Negligible.
	Generation of oily waters.	Will occur.	Adherence to MARPOL, Resource Management (Marine Pollution) Regulations 1998, approved IOPPC and SOPEP.	Negligible.
Atmospheric emissions.	Atmospheric emissions.	Will occur.	Approved IAPPC. Regular maintenance of motors, equipment and generators and monitoring of fuel consumption.	Negligible.
Unplanned Activities				
Streamer break or loss.	Water or seabed impact.	Low.	Solid streamer with SRD fitted and support vessel present at all times.	Negligible.
Fuel or oil spills.	Water and coastal impact.	Low due to mitigation measures.	Compliance with COLREGS and SOPEP in place.	Negligible.
Vessel collision or sinking.	Water and coastal impact.	Extremely unlikely.	24/7 operations to minimise duration of survey. Compliance with COLREGS and support vessel present at all times. Notice to Mariners issued and broadcast on Maritime Radio. All users of Waru Operational Area have been advised of the Waru 2D MSS operation.	Negligible.

6 Environmental Management Plan

The management of environmental risks associated with NZOG'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. These mechanisms ensure that NZOG's high environmental standards are maintained, the commitments specified in this MMIA are achieved and that any unforeseen aspects of the proposed Waru 2D MSS are detected and addressed.

The Environmental Management Plan (EMP) is essential for the successful implementation of the Waru 2D MSS; highlighting the key environmental objectives, the mitigation measures and monitoring programmes to be followed as well as the regulatory and reporting requirements and commitments outlined in this MMIA.

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

The *Aquila Explorer* also has its own independent EMP which documents 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 Waru 2D MSS is provided in Table 10 and will be undertaken in conjunction with the MMMP (Appendix 4).

6.1 Implementation

All contractors involved in the Waru 2D MSS have their own management systems that are consistent with the requirements of the Waru 2D MSS. To ensure environmental performance and before any contracts were signed NZOG assessed contractors previous environmental performance; included clauses in the contract documents specifying contractor responsibilities; indicated the requirements for contractor training and the requirements for appropriate monitoring, feedback and sharing information between NZOG and the contractor (i.e. marine mammal reports and weekly waste-generation reports).

The *Aquila Explorer* will have specific personnel with designated responsibilities in regard to environmental protection, supervision and execution of the EMP. However, the Master will have ultimate responsibility for ensuring the *Aquila Explorer* is operated with a high regard for environmental protection.

The Waru 2D MSS will be conducted in accordance to (but not limited to) the Code of Conduct, all relevant Maritime regulations, Marine Protection Rules, Resource Management (Marine Pollution) Regulations 1998, Environmental Best Practice Guidelines for the Offshore Petroleum Industry (MfE, 2006) and the Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 2013 (HSE, 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 acoustic source.

Table 10: Waru 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 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 (last slipped in November 2013). Adherence to ballast water regulations. Regular maintenance undertaken.	International best practice. Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993). Draft Craft Risk Management Strategy for Vessel Biofouling.
Minimise disruption and physiological effects to marine mammals and marine fauna.	Presence of marine mammals within mitigation zones while acoustic source is active.	Continuous observation by qualified observers. Use of PAM 24/7.	Compliance with Code of Conduct and Section 5.3.2. 24/7 operation to minimise MSS duration. Presence of two qualified MMOs for daylight observations 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.
Minimise effects on sea water quality.	Liquid wastes.	Continuous.	Discharge to sea in accordance with MARPOL and NZ regulations.	MARPOL 73/78. Resource Management (Marine Pollution) Regulations 1998. NZ Maritime Transport Act 1994.
	Oil and other waste.	Continuous.	Disposed at an approved shore reception facility in compliance with legal procedures and maintain a waste disposal log. Approved SOPEP and IOPPC.	MARPOL 73/78. Resource Management (Marine Pollution) Regulations 1998. NZ Maritime Transport Act 1994.
	Bio-degradable wastes.	Continuous.	Can be discharged overboard beyond 12 Nm from the coastline or 3 Nm if comminuted.	MARPOL 73/78. Resource Management (Marine Pollution) Regulations 1998. 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.
	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. Resource Management (Marine Pollution) Regulations 1998. 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 Ice Class. Solid streamer used with SRD's fitted. COLREGS and presence of a support vessel. Approved SOPEP in place.	Best Practice. COLREGS.

7 Conclusion

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

For the Waru 2D MSS, NZOG will comply with the Code of Conduct, NZ Maritime Rules, NZ Marine Protection rules, Resource Management (Marine Pollution) Regulations 1998, NZOG's internal HSE documents and implement international best practice to ensure there is no harm to any marine mammals, marine fauna, the marine environment or any personnel.

As well as adhering to the Code of Conduct, NZOG will implement additional mitigation measures as a reflection of conducting the Waru 2D MSS in an AEI. The mitigation zone for Species of Concern with calve within the Code of Conduct for a Level 1 MSS has been validated by STLM; however the radius of the mitigation zone for Species of Concern (without calve) was increased to 1.5 km to ensure compliance with the mitigation thresholds within the Code of Conduct is achieved. As a result compliance with the amended mitigation zones for the Waru 2D MSS should not result in any injury to marine mammals. NZOG will have four independent and suitably qualified MMO's 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 that has advanced seismic acquisition technology and 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 Waru 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, it is believed that the potential for any adverse effects on the marine environment or marine mammals are ***negligible*** or ***minor*** if the Waru 2D MSS is undertaken in compliance with the Code of Conduct and the mitigation measures discussed in this MMIA.

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Appendices

This report contains the following appendices.

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

APPENDIX 1

Waru 2D MSS Information Sheet

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

New Zealand Oil & Gas Limited
Waru 2D Marine Seismic Survey – South Taranaki Bight
Information Sheet

Environmental Offshore Services Limited (EOS) has been engaged by New Zealand Oil & Gas Limited (NZOG) to prepare a Marine Mammal Impact Assessment (MMIA) for a 2D Seismic Survey in the South Taranaki Bight (Figure 1).

The Waru 2D Seismic Survey will be located within Petroleum Exploration Permit 54857, where approximately 435 lineal km of 2D seismic survey lines will be acquired. The purpose of the Waru 2D survey is to gather a general understanding of the regional geological structures and identify more prospective areas for hydrocarbons which can be comprehensively assessed at a later stage through a 3D seismic survey. Figure 1 shows the operational area within which the Waru 2D Seismic Survey will occur with the proposed survey lines shown.

The Waru 2D Seismic Survey is scheduled to commence in March 2014 and will take approximately 5 days to complete depending on weather constraints and marine mammal encounters. NZOG have contracted the seismic vessel *Aquila Explorer* to undertake the 2D seismic survey, a well-established seismic survey vessel (Figure 2). The 71 m *Aquila Explorer* will tow one streamer, up to 8 km long just below the surface behind the vessel that will restrict its ability to manoeuvre. The end of the streamer is marked with a tail buoy that can be observed day and night due to a flashing light and radar reflector. During seismic acquisition the vessel will be travelling at approximately 4.5 kts so the streamer tail buoy will be travelling approximately 50 minutes behind the vessel.

The support vessel *Amaltal Mariner* (Figure 3) will accompany the *Aquila Explorer* to ensure the survey area is clear of obstructions and inform other users of the presence of the seismic vessel if they cannot be contacted via VHF radio. A Notice to Mariners will be issued and will be broadcast daily on maritime radio advising of the Waru 2D Seismic Survey for the duration of the survey.

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 it 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.

NZOG will operate the Waru 2D Seismic Survey in accordance to the '2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Operations' (Code of Conduct). Under the EEZ Act 2013, seismic surveys are classified as Permitted Activities as long as the operator complies with the Code of Conduct. This requires a MMIA to be prepared and that the mitigation measures for a Level 1 seismic survey under the Code of Conduct are adhered to in order to prevent any adverse effects on the marine environment or marine mammals. The Director-General of Department of Conservation has to give formal sign off to the MMIA before the Waru 2D Seismic Survey can commence.

P.O. Box 2065 Nelson 7041

+64 (0) 274 898 628 www.eosltd.co.nz

Contact Details

If you have any further questions or matters you would like to discuss or you would like any further information in regards to the Waru 2D Seismic Survey, please contact Dan Govier of EOS.

Dan Govier
Environmental Consultant
Environmental Offshore Services Ltd

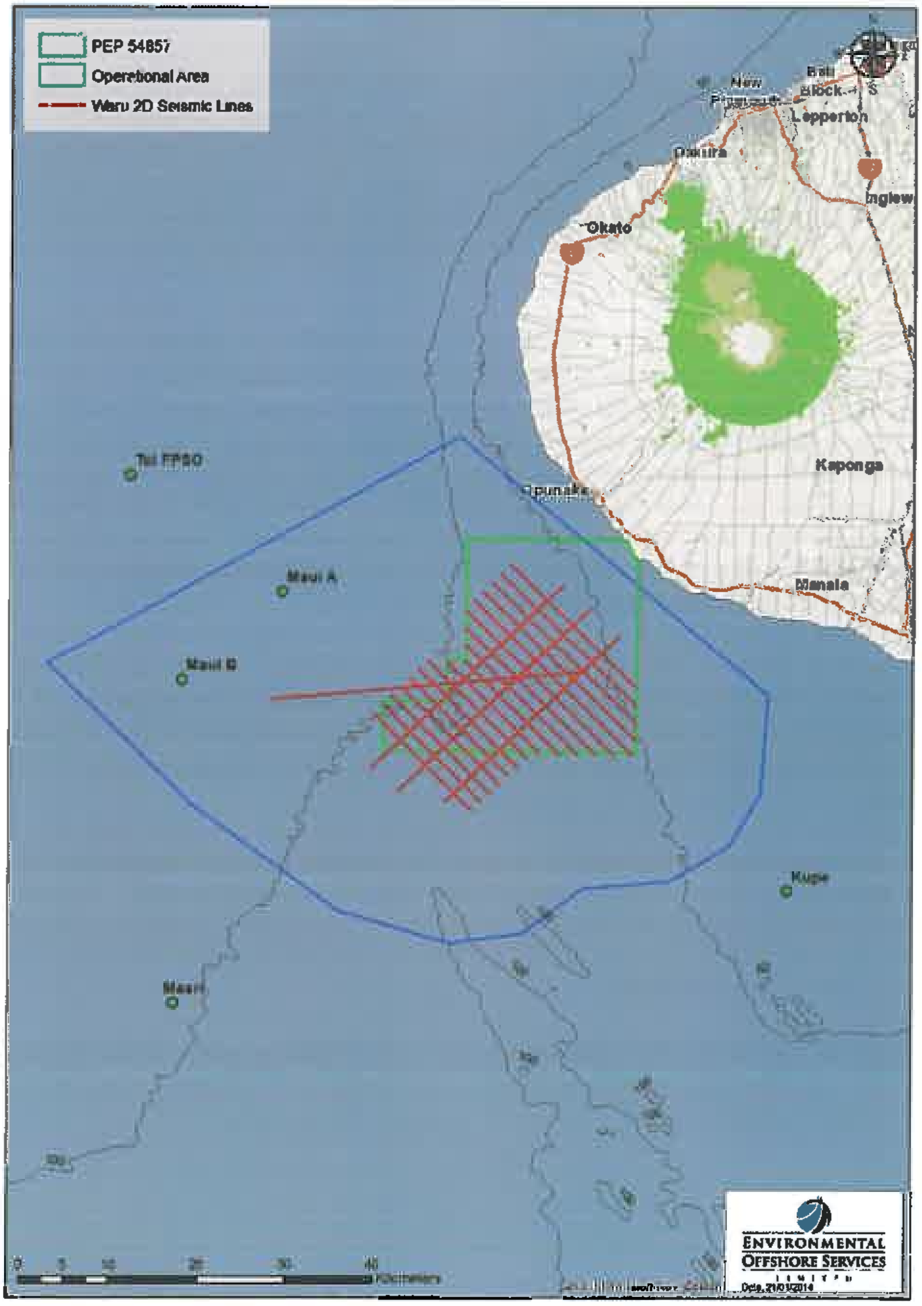

Figure 1: Waru 2D Seismic Survey and Operational Area

Figure 2: Seismic Survey Vessel – ***Aquila Explorer***

Figure 3: Support Vessel – ***Amaltal Mariner***

APPENDIX 2

Consultation Register with Key Stakeholders

Stakeholder	Consultation Summary
Nga Ruahine Iwi Authority	Introduced NZOG and the proposed Waru 2D MSS to Nga Ruahine. Nga Ruahine suggested NZOG engage with the two local hapu directly inshore of the Waru Operational Area. Contact details were provided and this engagement is ongoing.
DOC – Taranaki Office 23/01/2014	Gave an overview of proposed 2D MSS and Survey Area. Discussed potential sensitivities and the mitigation measures that will be in place for the duration of the survey.
Taranaki Regional Council 23/01/2014	Introduced the Waru Operational Area, given the survey is partly within the CMA and in case the TRC receive phone calls about the activity. TRC will be provided with further survey details and contact numbers should they require any more information.
Egmont Seafoods 23/01/2014	Introduced the Waru 2D MSS and proposed timing of survey to see if it will clash with any of their fishing activities. Closer to survey commencement Egmont Seafoods will be contacted with the expected start date to avoid any conflicts. A number of maps showing the survey area were left to be distributed to the fisherman.
Port Taranaki 23/01/2014	An overview of NZOG and the proposed Waru 2D MSS was provided to Port Taranaki. Given that they also have vessels which operate down in that part of the coastline that either undertake surveys or visit the offshore facilities.
Taranaki Iwi Trust 24/01/2014	An overview of NZOG and their history in Taranaki was provided. The Waru 2D MSS project was introduced and the Waru Operational Area, which is close to a rohe moana gazetted by one of the Taranaki hapu. This section of the coastline inshore of the Waru Operational Area has important reefs for customary kaimoana gathering and important Tauranga waka sites. Concerns were raised over effects of seismic noise on kaimoana, and stated this is the biggest concern to iwi. A hui is going to be held with the hapu that set up the rohe moana.
Ngati Haua	Provided an overview of NZOG and the proposed Waru 2D MSS. A number of questions were answered from the hapu and more information is to be provided to the hapu as well as a copy of this MMIA once finalised.
Ngati Tamaahuroa me Titahi & Ngati Haumia 12/03/2014	Held a combined hui with Ngati Tamaahuroa me Titahi and Ngati Haumia at the Orimupiko marae. This hui had been requested prior to the email reply from Ngati Tamaahurao me Titahi above and was a follow up on that email request to meet as well. NZOG was introduced to both representatives of the two hapu and the history of NZOG in the Taranaki area and the consultation undertaken to date over recent years around the block offers, and at the iwi level regarding the proposed Waru MSS. The Waru MSS survey area was introduced and the proposed MSS was discussed in relation to the timing, process, mitigation measures, regulatory requirements etc. NZOG also provided a summary of how the block offer system, permits and work commitments work and fit into the programme to provide some background and context. Sensitivities of the area were discussed in relation to kaimoana from oil and gas exploration, traditional fishing grounds and the migration of longfin eels and glass eels around the Taranaki coastline. The individual hapu boundaries were explained and identified on the survey map. NZOG will look to establish further engagements with the hapu's and the MMIA will be provided to them once finalised as well as being kept updated of NZOG's activities within the area through their newsletter distribution. An offer was made that if required NZOG can revisit Taranaki to discuss the project with the wider hapu.
	Introduced the seismic survey area and provided the Information Sheet used in the consultation process.

University of Auckland	aid that the main sensitivities within the area could be Maui's dolphins and blue whales. said that assuming the Waru MSS is adhering to the Code of Conduct and has MMO's onboard, she cannot really comment on it as she is not directly involved with any work on these species.
University of Otago	The Waru MSS and the survey duration etc. was introduced to ınd she was sent the information sheet attached in Appendix 1. Discussion was held over the validation methods to the STLM and the process. is keen to be notified early with any surveys along the South Islands east coast so that students from the University can undertake research listening to sound levels at known distances to the source vessel as part of their own validation of the STLM, and to see how marine mammals respond to the sound source when the acoustic source is a long way away.

Dan Govier

From:
Sent:
To:
Subject:

Thanks Dan,
We will keep an eye on Waru but will not interfere with us for such a short time. Mohua will not have any impact at all.
Cheers

Compass Rose Fishing Ltd.

From: Dan Govier <dan@eosltd.co.nz>

Sent: Monday, 3 March 2014 3:40 PM
Subject: Seismic Surveys March 2014

Hi all,

Please find information attached for two proposed 2D seismic surveys which will be undertaken by New Zealand Oil & Gas Ltd and OMV NZ Ltd

The seismic surveys are proposed to be undertaken in the middle to late March 2014 in the South Taranaki Bight.

The seismic survey vessel *Aquila Explorer* will be used for both surveys, where it will undertake NZOG's Waru 2D Seismic Survey first and then move offshore to complete OMV's Mohua 2D Seismic Survey.

The surveys will only occur for a short duration, the inshore Waru Seismic Survey is proposed to take five days, while the offshore Mohua Seismic Survey is expected to take three days.

A Notice to Mariners will be issued and a tail buoy with lights and a radar reflector will mark the end of the single seismic streamer being towed.

If you have any questions or concerns over the attached sheet please let me know

Cheers
Dan

Dan Govier

From: Idq#Dqjxv
Sent: Iulgd|/#43#Mdqxdu|#5347#k=63#dp 1
To: Gdq#Jryhu
Cc: Gdyh#Oxqgtxlvw#Z loldp #Dudgjh
Subject: UH=#Q]RJ#5G#Vhlvp lf#Vxuyh|#Qrwlilfdwlrq

Thanks for this notofication Dan

Manager Marine Species and Threats
Pou Koiora Waitai Mōrearea
Science and Capability Group
Department of Conservation—*Te Papa Atawhai*
DDI: +64 4 471 3081

National Office
PO Box 10 420, Wellington 6143
18-32 Manners St, Wellington 6011
T: +64 4 471 0726

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

www.doc.govt.nz

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursday, 9 January 2014 2:38 p.m.
To: Ian Angus
Cc: Dave Lundquist
Subject: NZOG 2D Seismic Survey Notification

Hi Ian,
Please find attached a notification letter for the Director-General advising of NZOGs intentions to acquire a 2D seismic survey within Petroleum Exploration Permit 54857.

Thanks
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 898 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Mrkq#Fdhdd##IYP V
Sent: P rqgd|/#6#P dufk#5347#7=53#s1p 1
To: *Vhujh1#Vkhdnvw#*#Yddnul#Ehary*#Wlp #Ddz *#Kdp lvk#Wlvhq*#ER \OH/#Grqdo*
Cc: *Ulfkdug#Z hov*#Gdq#J rylhu*
Subject: IZ =#Vhlvp lf#Vxuyh|v#P dufk#5347
Attachments: Z dux#5G#Lqirup dwlrq#Vkhhw1sgi#P rkxd#5G#Lqirup dwlrq#Vkhhw1sgi

Hi all

Just quick note, for those who might have vessels on JMA7 , Seismic survey off the South Taranaki Bight mid to late March/ shouldn't effect deepsea trawlers, at that time, position looks shallow water & close to shore, but just in case areas/positions attached

F.V. Management Services Ltd
12 Duncan Street Port Nelson
PO Box 1279 Nelson 7040

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 3 March 2014 3:41 p.m.

Subject: Seismic Surveys March 2014

Hi all,

Please find information attached for two proposed 2D seismic surveys which will be undertaken by New Zealand Oil & Gas Ltd and OMV NZ Ltd

The seismic surveys are proposed to be undertaken in the middle to late March 2014 in the South Taranaki Bight.

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If you have any questions or concerns over the attached sheet please let me know

Cheers
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 898 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Odz v#Iqvkruh,
Sent: P rqgd|/#6#P dufk#5347#7=46#s1p 1
To: 'Gdq#J rylhu'
Cc: mhuhp|C lqvkruh1fr1q}
Subject: UH=#Vhlvp lf#Vxuyh|v#P dufk#5347

Dan

Please note new email address as above.

is now the new CE for Fisheries Inshore New Zealand Ltd

regards

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 3 March 2014 3:41 p.m.

Subject: Seismic Surveys March 2014

Hi all,

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If you have any questions or concerns over the attached sheet please let me know

Cheers
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 898 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041
ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Sdw#J doolj khu
Sent: Z hgqhvgd|/#59#Iheuxdu|#5347#45=83#s1p 1
To: gdqC hrvog1fr1q}#wxp h;3C {wd1fr1q}#uC rsxqdnh1vfkrrdq}# nkurqjrqxlC jp dlofrp #wduddz dud93C jp dlofrp #jkp dqxC fdndulqhwiq}# nlqnlqvlp dqdC {wd1fr1q}#z1hz1hgz dugvC p dvvh|1lf1q}
Cc: mxqhkrrnhuC lqvslh1qhwiq}#vdp 1erz duC q}rj 1frp
Subject: UH#Q] R J #Vhlvp lf#Vxuyh|

Hi Dan. Thank you.This looks more than satisfactory to me as a possible way forward. Cheers

----
On Mon, Feb 17, 2014 8:24 PM NZDT Dan Govier wrote:

>H
>
>That is ok, looks like this meeting will not go ahead.
>
>
>
>What we can do, as you suggested, is put some information together and
>send it up to you electronically so you can see some further details of
>the proposed seismic survey. We can send an information sheet, which
>is a quick summary explaining what is proposed and where the survey
>area is located, and we can then provide a final draft version of our
>Marine Mammal Impact Assessment which we are currently preparing once
>we have some sound loss modelling completed etc.
>
>
>
>If you have any further questions following that, we can try to arrange
>a conference call or phone call for further discussion.
>
>
>
>Hopefully this way forward is satisfactory to you all.
>
>
>
>Thanks
>
>Dan
>
>
>
>*From:
>*Sent:* Sunday, 16 February 2014 8:45 p.m.
>*To:* 'Dan Govier': '
>
>

>*Subject:* RE: NZOG Seismic Survey
>
>
>
>Hi Dan
>
>
>
>Regrettably I will not be able to attend a meeting on 22 or 23 February.
>Would it be possible to send a soft copy of your proposed presentation
>so that we can identify anything that might be of concern?
>
>
>
>Cheers
>

>
>
>
>*From:* Dan Govier [mailto:dan@eosltd.co.nz <dan@eosltd.co.nz>]
>*Sent:* Saturday, 15 February 2014 9:29 p.m.
>*To:*
: -
>
>*Subject:* RE: NZOG Seismic Survey
>
>
>
>Thank you for letting me know.
>
>
>
>Is anyone else able to attend a meeting on the weekend of late
>afternoon/evening of Saturday 22nd February or on Sunday 23rd February?
>
>
>Nga mihi,
>

>
>
>
>
>*Sent:* Monday, 10 February 2014 9:32 p.m.
>*To:* 'Dan Govier';

>*Subject:* RE: NZOG Seismic Survey
>
>
>
>Teenaa koe Dan I am unable to meet on the dates proposed because of
>other hui - Kia ora ra

>
>
>

>

>

>
>
>
>
>-------------------------------
>
>*From:* Dan Govier [mailto:dan@eosltd.co.nz <dan@eosltd.co.nz>]
>*Sent:* Monday, 10 February 2014 9:31 p.m
>*To:

:
>*Subject:* RE: NZOG Seismic Survey
>
>Tēnā koutou,
>
>Just following up on a meeting with you all regarding NZ Oil & Gas
>seismic survey scheduled for the middle of March.
>
>We are meeting with Ngati Haua on Saturday 15th of February and was
>wondering if you would be available to meet on late afternoon/evening
>of Saturday 22nd February or any time Sunday 23rd February?
>
>If you could please let me know as soon as possible if this suits, that
>would be appreciated.
>
>Nga mihi
>
>
>
>[image: cid:image001.jpg@01CED491.B0262780]
>
>
>
>
>
>
>
>
>
>*From:* Dan Govier [mailto:dan@eosltd.co.nz]
>*Sent:* Tuesday, 28 January 2014 10:15 a.m.
>*To:* '
>'Ngaw

>*Subject:* RE: NZOG Seismic Survey
>

> Tēnā koutou,
>
> I am an environmental consultant working with New Zealand Oil & Gas
>regarding a proposed seismic survey happening off the coast south of
>Opunake in March this year.
>
>We will be up in Taranaki on *Tuesday 11th February* and would like to
>come and visit you. The purpose of the hui is to introduce New Zealand
>Oil & Gas, provide an overview of what seismic surveys are and what
>they are looking for etc, what the potential sensitivities are and the
>mitigation measures that will be in place for the 5 day survey and to
>listen to any concerns questions you may have.
>
>· We could visit Ngati Tamaahuroa/Titahi, Oeo marae in the morning
>at *9am*.
>
>· Then we could visit Ngati Haua hapu/Tawhitinui Pa, Okare ki uta
>(Taikatu ki uta) in the afternoon, maybe *12-30 or 1pm*
>
>How does that sound with everyone?
>
>If you are available to meet if someone from each respective hapu could
>please provide me with address/contact details for the hui's that would
>be greatly appreciated.
>
>Nga mihi
>
>Dan
>
>[image: cid:image001.jpg@01CED491.B0262780]
>
>
>
>*From:*
>
>
>*Sent:* Friday, 24 January 2014 7:47 p.m.
>*To:* 'Dan Govier';

>*Subject:* RE: NZOG Seismic Survey
>
>
>
>Tena koe Dan,
>
>Enjoyed yesterdays hui,
>
>Seismic survey;
>
>Contact needs to be made with haukainga manawhenua hapu
>
>1/Ngati Haua hapu/Tawhitinui Pa, Okare ki uta (Taikatu ki uta)
>(contact details on To line)

>
>2/Ngati Tamaahuroa/Titahi, Oeo marae (contact details on 2nd line cc)
>
>
>
>Over our Ngaruahine border contact with Taranaki Iwi and Orimupiko
>Marae (last 3 addresses on bottom line)
>
>
>
>Naku iti nei
>
>
>

Dan Govier

From: Wlp#Ddz
Sent: P rqgd|/#5#P dufk#5347#7=3;#sp 1
To: Gdq#Jrylhu
Subject: UH=#Vhlvp lf#Vxuyh|v#P dufk#5347

Thank you Dan,
Our vessel is currently in the area but may have left by Mid-March.
Please update on the start date when it becomes clear.
Tim

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 3 March 2014 3:41 p.m.

Subject: Seismic Surveys March 2014

Hi all,

Please find information attached for two proposed 2D seismic surveys which will be undertaken by New Zealand Oil & Gas Ltd and OMV NZ Ltd

The seismic surveys are proposed to be undertaken in the middle to late March 2014 in the South Taranaki Bight.

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The surveys will only occur for a short duration, the inshore Waru Seismic Survey is proposed to take five days, while the offshore Mohua Seismic Survey is expected to take three days.

A Notice to Mariners will be issued and a tail buoy with lights and a radar reflector will mark the end of the single seismic streamer being towed.

If you have any questions or concerns over the attached sheet please let me know

Cheers
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 398 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041
ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From:	Mrkq#Krrnhu
Sent:	Iulgd|/#57#Mdqxdu|#5347#<=7:#sp1
To:	*Gdq#Jryhu*#Fodl#Uhl*#Zhqg|#H|qrq*#Ndu#Dgdpvrq*#Qjdzdl#Khqduh#WGKE*# *Tudqfhv#Nlqjl#Ndwhqh*#hudxCwhudxsdqlfrlq}
Cc:	*Udqjlurd#Urqjrqxl*#Ndwdudlqd#KrxlOUrqjrqxl*#Wdudzdud#Zhvwrq*#jkpdqx*# *Pdqd#Mhqnlqv*#Sdw#Jdooljkhu*#Wh#Sdkxqjd#PZ#Gdylv*#Hgzdugv/#Zlo*#Goqh# Udwdkl*#Mrkqdwkrq#Pxud|*#Wrndwxp rdqd#Zdghq*
Subject:	UH=#Q]RJ#Vhlvplf#Vxuyh|

Tena koe Dan,
Enjoyed yesterdays hui,
Seismic survey;
Contact needs to be made with haukainga manawhenua hapu
1/Ngati Haua hapu/Tawhitinui Pa, Okare ki uta (Taikatu ki uta) (contact details on To line)
2/Ngati Tamaahuroa/Titahi, Oeo marae (contact details on 2nd line cc)

Over our Ngaruahine border contact with Taranaki Iwi and Orimupiko Marae (last 3 addresses on bottom line)

Naku iti nei

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursday, 23 January 2014 5:36 a.m.
To:
Subject: RE: NZOG Seismic Survey

Kia ora
Nice to see you again yesterday, and thanks once again for your time.

Just following up on the meeting, are you able to provide me with the contact details for the two hapu that we need to visit in regards to the proposed seismic survey.

Thanks very much,

Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 20 January 2014 11:20 a.m.

Cc:
Subject: RE: NZOG Seismic Survey

Hi
Further to my email previously, it has now been confirmed that CEO of NZ Oil & Gas is available to head up to NP this Wednesday (22nd) to meet with you.

We would arrive at NP airport on the 12-30pm flight and head straight down to Manaia, so we could have a 2pm meeting?

However, we would have to leave by 4pm to ensure that can catch the flight out of NP.

I hope this timing is ok and I am sure we can cover all we need to in that time frame.

Thanks
Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Friday, 17 January 2014 8:41 p.m.

Cc: t
Subject: NZOG Seismic Survey

Kia ora
Happy New Year, I hope you had a good break over the Christmas/New Year period.

I just wanted to touch base with you, New Zealand Oil & Gas are planning to undertake a 2D seismic survey off South Taranaki in the middle of March and we would like to come and visit you down in Manaia to introduce the proposed survey and answer any questions or concerns you may have.

The survey is just south of Opunake within PEP 54857 and it is closer to shore than some of the more recent seismic surveys.

the Chief Executive of NZOG is available to travel up to New Plymouth on Friday 24th of January, how would that suit with you, would you be available to meet with us? It would be early afternoon that we would be able to get to your office.

If you could please let me know whether you are available to meet with us on Friday afternoon that would be greatly appreciated.

Nga mihi,
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 858 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Mrkq#Krrnhu
Sent: P rqgd|/#53#Mdqxdu|#5347#4=37#s1p 1
To: *Gdq#J rylhu*#qjduxdklqhlz lC {wud1fr1q}
Cc: whrwlC z lqgrz vdyh1frp *#Sdp #Z kdhsdsd*#Wdudz dud#Z hwrq*#jkp dqx*#Z hkl# Wdndp rul*#P dqd#Mhqnlqv*#z duhq#q1fkrov*#Orcd#Ndwhqh*
Subject: UH#Q] R J #Vhlvp lf#Vxuyh|

Tena koe Dan,

2 pm this Wednesday at Manaia will be fine to touch base, our trustees may also be in attendance

Regards

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 20 January 2014 11:20 a.m.

Cc:
Subject: RE: NZOG Seismic Survey

Hi

Further to my email previously, it has now been confirmed that CEO of NZ Oil & Gas is available to head up to NP this Wednesday (22nd) to meet with you.

We would arrive at NP airport on the 12-30pm flight and head straight down to Manaia, so we could have a 2pm meeting?

However, we would have to leave by 4pm to ensure that can catch the flight out of NP.

I hope this timing is ok and I am sure we can cover all we need to in that time frame.

Thanks
Dan

From:
Sent: Saturday, 18 January 2014 3:38 p.m.
To: 'Dan Govier'; ngaruahineiwi@xtra.co.nz
Cc:
Subject: RE: NZOG Seismic Survey

Dan would love to meet with you however that time is taken, are you able to forward a range of alternative dates, am free on Jan 22nd,31st, Feb 7th,11th,12th, 13th, 14th

Regards

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Friday, 17 January 2014 8:41 p.m.
To
Cc:
Subject: NZOG Seismic Survey

Kia ora
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www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Olqgd#Hqjdu
Sent: Wkxuvgd|/#46#Iheuxdu|#5347#k=87#dp 1
To: Gdq#Jryhu
Cc: Nduo#Flod#Uhl#Fkulvwlqh#Khqduh#Wh#Jdx#Wdl#Ohljk#P lvv|#Vsrrqhu#Ud|
Subject: UH=#Lqylwh#wr#Qjdwl#Kdxd#Kxl#48wk#Ihe

Kia ora Dan

Yes meeting is on:

Venue: Tawhitinui Marae, 2453 South Road (Surf Highway), Otakeho.
Time: 12.30pm
Date 15th February 2014

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursday, 13 February 2014 8:48 a.m.
To:
Cc: :
Subj...

Kia or...
Just following up on the proposed hui with you this Saturday.

Can you please confirm the meeting time and venue?

As we need to arrange travel and accommodation for this Saturday if the hui is still on.

Nga mihi
Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Mondav. 10 February 2014 2:53 p.m.
To:

Subject: RE: Invite to Ngati Haua Hui 15th Feb

Kia ora
That sounds good for Saturday thank you, unfortunately I will not be able to attend this Saturday, however the Chief Executive of NZ Oil & Gas and the geologist who is running the project will attend.

Can you please provide me with the meeting details so that I can pass on for their travel arrangements.

Nga mihi
Dan

Dan Govier
Environmental Consultant
+64 (0) 274 898 628
www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

From.
Sent: Monday, 10 February 2014 11:36 a.m.
To: dan@eosltd.co.nz
Cc: K
Subject: Invite to Ngati Haua Hui 15th Feb

Kia ora Dan

On behalf of Ngati Haua Hapu, in response to your request, we would like to invite you to a hui this Saturday 15th Feb 2014 at 21.30pm.

Ngaa mihi
Secretary

Dan Govier

From: Ndud
Sent: P rqgd|/#6#Iheuxdu|#5347#:=35#dp 1
To: Gdq#Jryhu#Mrkq#Krrnhu#Fkd#Uhl#Z hqg|#H|qrq#Qjdzdl#Khqduh#WGKE'#Iudqfhv# Nlqj1#Ndwhqh#whudxC whudxsdql1fr1q}
Cc: Udqjlird#Urqjrqxl#Ndwdulqd#Krxl0Urqjrqxl#Wdudzdud#Z hwrq#Jkpdqx#P dqd# Mhqnlqv#Sdw#Jdoodjkhu#Wh#Sdkxqjd#P Z #Gdylv#Hgzdugv#Z lo
Subject: UH#QJRJ#Vhlvp lf#Vxuyh|

Hey Dan,

This date is not suitable for Ngati Haua due to the majority of our uri being at work, the best we could accommodate would be a Saturday, as yet the hapu hasnt set a meeting schedule for this year however we may have that clarified this weekend. Can you advise when you are looking at beginning this activity?

Sent from my Ipad

-------- Original message --------
From: Dan Govier <dan@eosltd.co.nz>
Date:
T
<

Cc

Subject: RE: NZOG Seismic Survey

Tēnā koutou,

Just following up on my email below and wondering if anyone will be available to meet with us to discuss the proposed seismic survey on these dates below when we will be up in Taranaki?

Nga mihi,

Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Tuesday, 28 January 2014 10:15 a.m.

Cc

Subject: RE: NZOG Seismic Survey

Tēnā koutou,

I am an environmental consultant working with New Zealand Oil & Gas regarding a proposed seismic survey happening off the coast south of Opunake in March this year.

We will be up in Taranaki on **Tuesday 11th February** and would like to come and visit you. The purpose of the hui is to introduce New Zealand Oil & Gas, provide an overview of what seismic surveys are and what they are looking for etc, what the potential sensitivities are and the mitigation measures that will be in place for the 5 day survey and to listen to any concerns questions you may have.

- We could visit Ngati Tamaahuroa/Titahi, Oeo marae in the morning at **9am.**

- Then we could visit Ngati Haua hapu/Tawhitinui Pa, Okare ki uta (Taikatu ki uta) in the afternoon, maybe **12-30 or 1pm**

How does that sound with everyone?

If you are available to meet if someone from each respective hapu could please provide me with address/contact details for the hui's that would be greatly appreciated.

Nga mihi

Dan

Dan Govier
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www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

From:
Sent: Friday, 24 January 2014 7:47 p.m.

Cc: 'R
(

Subject: RE: NZOG Seismic Survey

Tena koe Dan,

Enjoyed yesterdays hui,

Seismic survey;

Contact needs to be made with haukainga manawhenua hapu

1/Ngati Haua hapu/Tawhitinui Pa, Okare ki uta (Taikatu ki uta) (contact details on To line)

2/Ngati Tamaahuroa/Titahi, Oeo marae (contact details on 2nd line cc)

Over our Ngaruahine border contact with Taranaki Iwi and Orimupiko Marae (last 3 addresses on bottom line)

Naku iti nei

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Thursdav. 23 January 2014 5:36 a.m.
To:
Subject: RE: NZOG Seismic Survey

Kia ora

Nice to see you again yesterday, and thanks once again for your time.

Just following up on the meeting, are you able to provide me with the contact details for the two hapu that we need to visit in regards to the proposed seismic survey.

Thanks very much,

Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 20 January 2014 11:20 a.m.
To:
Cc: t
Subject: RE: NZOG Seismic Survey

Hi

Further to my email previously, it has now been confirmed that CEO of NZ Oil & Gas is available to head up to NP this Wednesday (22nd) to meet with you.

We would arrive at NP airport on the 12-30pm flight and head straight down to Manaia, so we could have a 2pm meeting?

However, we would have to leave by 4pm to ensure that an catch the flight out of NP.

I hope this timing is ok and I am sure we can cover all we need to in that time frame.

Thanks

Dan

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Friday, 17 January 2014 8:41 p.m.
To:
Cc.
Subject: NZOG Seismic Survey

Kia ora ,

Happy New Year, I hope you had a good break over the Christmas/New Year period.

I just wanted to touch base with you. New Zealand Oil & Gas are planning to undertake a 2D seismic survey off South Taranaki in the middle of March and we would like to come and visit you down in Manaia to introduce the proposed survey and answer any questions or concerns you may have.

The survey is just south of Opunake within PEP 54857 and it is closer to shore than some of the more recent seismic surveys.

he Chief Executive of NZOG is available to travel up to New Plymouth on Friday 24th of January, how would that suit with you, would you be available to meet with us? It would be early afternoon that we would be able to get to your office.

If you could please let me know whether you are available to meet with us on Friday afternoon that would be greatly appreciated.

Nga mihi,
Dan

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www.eosltd.co.nz
P.O. Box 2065
Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Dodq#P hqrg|#SQ V#Q hz #Sd|p rxwk,
Sent: Wxhvgd|/#7#P dufk#5347#k=5;#dp 1
To: *gdqC hrvowg1fr1q}*
Cc: *Urz dq#\dqgdn*
Subject: IZ =#Vhlvp lf#Vxuyh|v#P dufk#5347
Attachments: P rkxd#5G#lqirup dwlrq#Vkhhw1sgi#Z dux#5G#lqirup dwlrq#Vkhhw1sgi

Thanks Dan, we appreciate the notice.
Whilst it does not directly affect us it is good to know what is going on.
I will pass it on to the committee at the next meeting,.

regards

President
New Plymouth Sportfishing and Underwater Club
New Plymouth

From:
Sent: Monday, 3 March 2014 6:08 p.m.

Subject: Fwd: Seismic Surveys March 2014

Begin forwarded message:

From: Dan Govier <dan@eosltd.co.nz>
Date: 3 March 2014 4:18:56 PM

Subject: Seismic Surveys March 2014

Hi all,

Please find information attached for two proposed 2D seismic surveys which will be undertaken by New Zealand Oil & Gas Ltd and OMV NZ Ltd

The seismic surveys are proposed to be undertaken in the middle to late March 2014 in the South Taranaki Bight.

The seismic survey vessel *Aquila Explorer* will be used for both surveys, where it will undertake NZOG's Waru 2D Seismic Survey first and then move offshore to complete OMV's Mohua 2D Seismic Survey.

The surveys will only occur for a short duration, the inshore Waru Seismic Survey is proposed to take five days, while the offshore Mohua Seismic Survey is expected to take three days.

If you have any questions or concerns over the attached information please let me know

Cheers

Dan

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Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Qhz#]hdodqg#Shwurdxp##P lqhudov
Sent: P rqgd|/#5#P dufk#5347#7=83#s1p 1
To: Gdq#Jryhu
Subject: UH=#Vhlvp lf#Vxuyh|v#P dufk#5347

Hello Dan,

Thank you for letting us know, I have sent the details on to the interested teams.

Regards,

Business Service Advisor, New Zealand Petroleum & Minerals
Ministry of Business, Innovation & Employment

Feedback on our service? Fill in our customer satisfaction survey.

Free email publications - http://www.nzpam.tx.co.nz/go/to/t/subscribe/

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 3 March 2014 4:08 p.m.
Tc

Subject: Seismic Surveys March 2014

Hi all,

Please find information attached for two proposed 2D seismic surveys which will be undertaken by New Zealand Oil & Gas Ltd and OMV NZ Ltd

The seismic surveys are proposed to be undertaken in the middle to late March 2014 in the South Taranaki Bight.

The seismic survey vessel *Aquila Explorer* will be used for both surveys, where it will undertake NZOG's Waru 2D Seismic Survey first and then move offshore to complete OMV's Mohua 2D Seismic Survey.

The surveys will only occur for a short duration, the inshore Waru Seismic Survey is proposed to take five days, while the offshore Mohua Seismic Survey is expected to take three days.

If you have any questions or concerns over the attached sheet please let me know

Cheers

Dan

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Nelson 7041

ENVIRONMENTAL OFFSHORE SERVICES LIMITED

Dan Govier

From: Gdq#Jryhu
Sent: Iulgd|/#:#Pdufk#5347#7=33#sp1
To: *Udqjlurd#Jrqjrqxl*
Subject: UH=#Zdlqjrqjrur#nl#Wdxqjdwdud#Qhz#]hdodqg#Rlo#)#Jdv#Olplwhg#Zdux#5G#Pdulqh#Vhlvplf#Vxuyh|#0#Vrxwk#Wdudqdnl#Eljkw

Tēnā Koe Rangiroa,

Thank you for your email below.

I have been speaking NZ Oil & Gas and the CEO of the company would like to talk with you. Do you have a mobile number or contact phone number he could reach you on?

He is travelling at the moment but can call you as soon as he has a phone number. We have tried the phone number at the bottom but realise that is for the Oeo Marae.

Nga mihi,
Dan

Dan Govier
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P.O. Box 2065
Nelson 7041
ENVIRONMENTAL OFFSHORE SERVICES LIMITED

From:
Sent: Friday, 7 March 2014 12:13 a.m.
To: dan@eosltd.co.nz
Subject: Waingongoro ki Taungatara New Zealand Oil & Gas Limited Waru 2D Marine Seismic Survey - South Taranaki Bight

Teena koe Dan,

You may not be aware of the historical context of the area in which you are undertaking your exploration, and the importance of the area to our people of Tamaahuroa and Titahi Hapuu. The fact is you are entering into the Ancestral Waters of the Ngaa Ruahinerangi people. The whole area is a restricted area (He Rahuimoana) for the people of the Ngaa Ruahinerangi Tribe. The rohe potae (identified area) **Waingongoro ki Taungatara** was gazetted by our forefathers as a place for the people of Ngaa Ruahinerangi to continue in the tradition of fishing. The area that has been identified in your email is directly adjacent to the fishing stations belonging to the Tamaahuroa and Titahi Hapuu (Sub Tribes) of the Ngaa Ruahinerangi and Taranaki Tribes, and the survey site identified on your map is directly over fishing grounds of the aforementioned hapuu and iwi.

The regulations which the Ministry of Conservation have identified as a matter of compliance for your exploration are attached to a different set of values to the values exercised by our hapuu. The Treaty of

Waitangi guarantees us the people of Tamaahuroa and Titahi the undisturbed rights to water and land; rights that can never be extinguished.

The intention of this correspondence is to inform you that the people of Tamaahuroa and Titahi hapuu are not in favour of Seismic Surveys in the immediate vicinity of our Ancestral Waters. Should you continue in your endeavours to carry out your survey without proper consultation, agreed upon by the affected parties namely Tamaahuroa, Titahi and our neighbouring hapuu Ngaati Haua then you will be in direct violation of the authority given to us to protect and maintain the quality of our ancestral waters.

Ooeo Paa is the meeting place for the Hapuu of Tamaahuroa and Titahi Hapuu. All matters of importance to our hapuu are discussed and agreed upon at this location. In the matter of Seismic Survey we the hapuu of Tamaahuroa and Titahi have a responsibility to guide and protect our takutai moana (seacoast) at all times. We ask that you meet with our hapuu to discuss the matter of Seismic Surveying in our Ancestral Waters.

Kaati ake (enough said)
noho ora mai,

Chairman of Oeo Paa Trustees, and Facilitator for Tamaahuroa and Titahi Hapuu Hui)

Dan Govier

From: Oldqd#Srxwx
Sent: Wxhvgd|/#58#Iheuxdu|#5347#43=77#dp 1
To: Gdq#Jrylhu
Subject: UH=#Q]RJ#Phhwlqj#gdwhv

Kia ora Dan,

Just letting you know that I have heard back from our Opunake hapu rep - who has advised that a meeting on 11 or 12 March at 7pm is most suitable. Can you please let me know availability from your end and I will confirm arrangements with them?

Nga mihi / Kind regards

-----Original Message-----
From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Friday, 21 February 2014 4:12 pm
To
Subject: Re: NZOG Meeting dates

Thanks
Yes I was picking that date might not suit given their busy weekend

Nga mihi
Dan

> On 21/02/2014, at 4:02 pm, Liana Poutu wrote:
>
> Kia ora Dan,
>
> Thanks for those dates. I will discuss these with the hapu over the weekend and let you know. I'm picking that Monday 24th won't be suitable.
>
> Nga mihi

>
> -----Original Message-----
> From: Dan Govier [mailto:dan@eosltd.co.nz]
> Sent: Friday, 21 February 2014 3:50 pm
> To:
> Subject: NZOG Meeting dates
>
> Kia ora l
> Just getting back to you regarding some proposed dates to visit the hapu in an evening up there for you to discuss this weekend.
>
> We are all available Feb 24th and 27th Or the week of March 10th-14th
>
> If any of these dates are available to the hapu if you could please let me know as soon as possible so arrangements can be made to get up there.
>

> Nga mihi
> Dan
>

Dan Govier

From: Oldqd#Srxwk
Sent: Wxhvgd|/#44#Iheuxdu|#5347#<=68#dp 1
To: Gdq#Jryhu
Subject: UH=#Kdsx#phhwlqj

Kia ora Dan,

We have an iwi meeting at Orimupiko on Saturday 22 Feb which finishes at about 1pm, I will check with the hapu whether they are able to stay on for a hui that afternoon. Sunday 23 Feb is definitely out for them as they have a major celebration at the marae that day.

Nga mihi

From: Dan Govier [mailto:dan@eosltd.co.nz]
Sent: Monday, 10 February 2014 9:34 pm
To: Li
Subject: Hapu meeting

Kia ora
Just following up in regards to a potential hapu meeting relating to the NZ Oil & Gas 2D seismic survey scheduled for March.

We are available to come up to NP for a later afternoon/evening meeting on Saturday 22nd February or any time on Sunday 23rd.

I have also sent these same times to Ngati Tamaahuroa/Titahi so hopefully we can accommodate both meetings in the one visit.

Nga mihi
Dan

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ENVIRONMENTAL OFFSHORE SERVICES LIMITED

APPENDIX 3

Technical Details of the PAM System

Appendix 2:

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 15-30Hz calls of large baleen whales to the 130kHz 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 0Hz to 3.2kHzs 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 20kHz 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

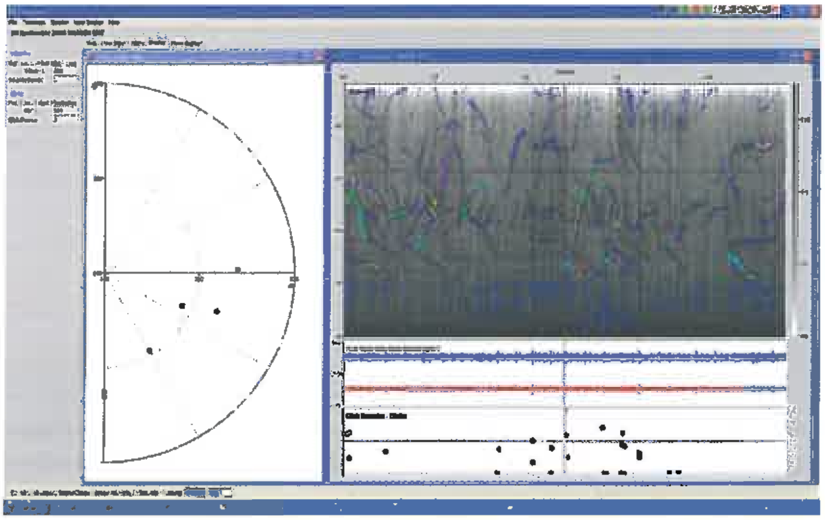
The system is optimised for use with PAMGUARD. A software suite specifically designed for detecting, classifying and localising a wide variety of marine mammals during seismic surveys. Much of the funding for the development came from the oil exploration industry. Ecologic was part of the team that initiated 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.



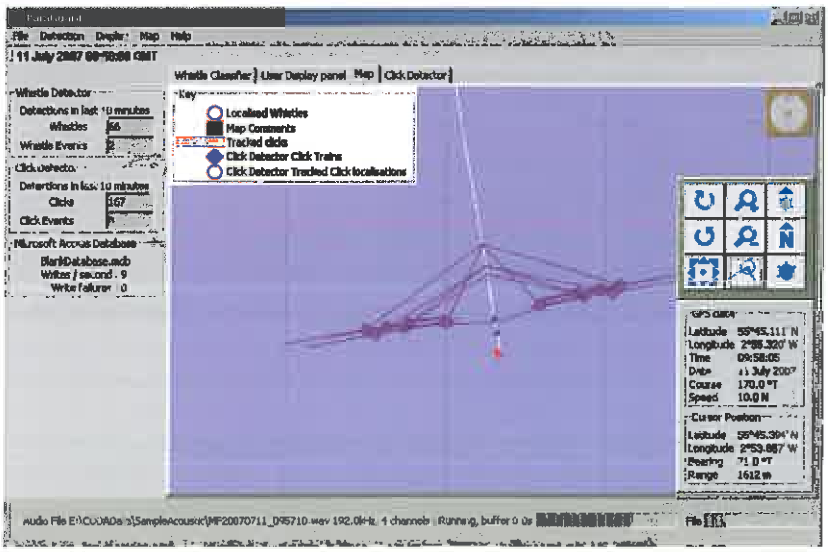


Figure 1 Screen shot from PAMGUARD Whistle and Click Detection and Mapping and Localisation Modules typical of a Seismic Mitigation configuration

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.

Standard Seismic Mitigation Acoustic Monitoring System	
Towed Hydrophone	
Acoustic Channels	2 x Medium Frequency Benthos AQ4. –201 dBV re 1?Pa (+/- 1.5 dB 1-15kHz) with Magrec HP02 broad band preamps (LF cut filter @ 100Hz or 50Hz as required) Near-flat Sensitivity 50Hz- 15kHz with good sensitivity to higher frequencies 2 x High Frequency Magrec HP03 units, comprising a spherical ceramic and HP02 preamp (Low cut filter set at 2kHz) Near flat sensitivity 2kHz- 150kHz. +/-6 dB 500Hz to 180kHz
Depth Sensor	Keller 4-20Ma 100m range Automatically read and displayed within PAMUARD
Streamlined housing	5m, 3 cm diameter polyurethane tube. Filled with Isopar M.
Cable	340m multiple screened twisted pair, with strain relief and Kellum's grip towing eye, Length deployed may vary to suit application
Connectors	19 pin Ceep IP68 waterproof
Deck cable	~75m 19pin Ceep to breakout box
Topside Amplifier Filter Unit	
Unit	Magrec HP/27ST
Supply Voltage	10-35 V DC
Supply current	200mA at 12 V

Standard Seismic Mitigation Acoustic Monitoring System	
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

APPENDIX 4

Marine Mammal Mitigation Plan for the Waru 2D MSS

Marine Mammal Mitigation Plan:

NZOG 54857 Waru 2D Marine Seismic Survey

BPM-14-NZOG-Waru 2D MSS-MMMP-v1.4

25/03/2014

BLUE PLANET MARINE

BLUE PLANET MARINE

Document Distribution List

Date: 25/03/2014

Title: Marine Mammal Mitigation Plan: NZOG 54857 Waru 2D Marine Seismic Survey

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BPM	David Paton, Managing Director	3
BPM	Simon Childerhouse, Senior Research Scientist	4
BPM	Rob Slade, Operations Manager	5

Document Revision Record

Rev.	Date	Description	Prepared	Reviewed	Approved
1.0	17/03/2014	Version 1	SC	DG, SB	
1.1	18/03/2014	Comments incorporated	LD	SC	SC
1.2	19/03/2014	Final version	SC	SB	SC
1.3	24/03-2014	DOC's comments incorporated	LD	SC	
1.4	25/03/2014	Final version	LD	SC	SC

Document Reference Number: BPM-14-NZOG-Waru 2D MSS-MMMP-v1.4

Prepared by: Simon Childerhouse

Last updated: 25 March 2014

www.blueplanetmarine.com

Table of Contents

List of Figures

List of Tables

List of Addenda

1. Introduction

This document has been developed by Blue Planet Marine (BPM) for New Zealand Oil & Gas 54857 (NZOG) in order to meet the requirements for a Marine Mammal Mitigation Plan (MMMP) for the Waru 2D Marine Seismic Survey (the survey). The survey area will be largely located within Petroleum Exploration Permit (PEP) 54857 with a proposed 35 km tie line to the Ruru-1 well within PEP 381203.

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 NZOG 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 MMO and PAM operators during a survey. This MMMP provides additional and supplemental information useful in the completion of MMO and PAM roles.

2. The NZOG 54857 Waru 2D Marine Seismic Survey

EOS was engaged by NZOG to prepare a MMIA for an approximate 435 line km survey in the South Taranaki Bight, scheduled to commence in March 2014. The survey area will be largely located within PEP 54857 with a proposed 35 km tie line to the Ruru-1 well within PEP 381203. Information provided in the draft MMIA for the Waru survey area has been used by BPM in the development of this MMMP.

The survey area will be bound by the Waru Operational Area; allowing for the operation of line turns, acoustic source testing and soft start initiation (Figure 1). It is anticipated that the survey will take approximately five days to complete, depending on weather constraints and marine mammal encounters. The actual commencement date of the survey is dependent on the seismic vessel, *Aquila Explorer*, completing prior surveys. The current schedule anticipates a commencement date of approximately 26th-27th March 2014, though this could be delayed.

The survey will acquire approximately 435 lineal km of 2D seismic data in order to provide a general understanding of the geological structure within PEP 54857. It will also identify more prospective areas for further investigation utilising a 3D MSS.

Approximately half of the survey area is within the New Zealand Exclusive Economic Zone (EEZ) while the inshore portion is within the Coastal Marine Area (CMA) administered by Taranaki Regional Council. The Code is not mandatory within the CMA, however, NZOG will adhere to it within the entire Waru Operational Area.

The *Aquila Explorer* will tow one solid streamer, 8 km in length. NZOG will utilise a 2,360 in^3 acoustic source comprising of four sub-arrays located at a depth of 8 m below the sea surface and >50 m behind the *Aquila Explorer*. In the case of dropouts during acquisition, the gun array may operate at a slightly lower capacity for a short period of time. The acoustic source will have an operating pressure of 2,000 psi and be fired at a shot point interval of 18.75 m apart, where for a typical boat speed of 4.2 – 4.5 knots, relates to a shot being fired every 8 – 8.5 seconds.

Given the volume of the airguns 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.

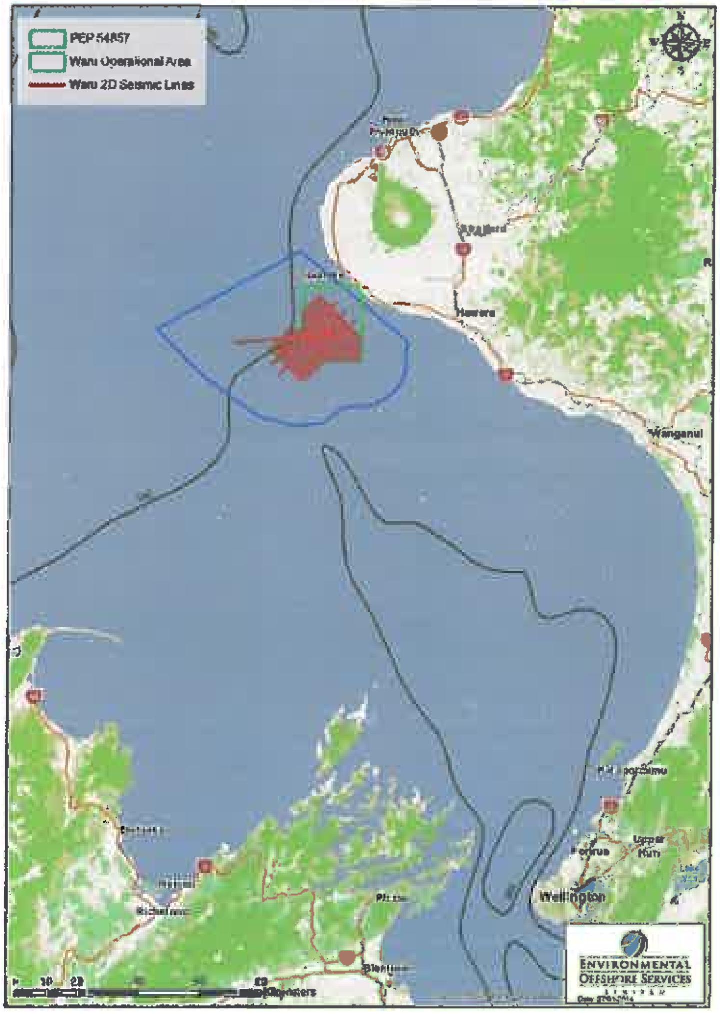


Figure 1: Location of the Waru 2D Marine Seismic Survey.

(Figure reproduced courtesy of EOS 2014. Observers to refer to the VADAR system for the coordinates of the survey Operational Area.)

3. Record Keeping and Reporting

The observers (MMOs and PAM operators) are responsible for maintaining records of all marine mammal sightings/detections and mitigation measures taken throughout each survey period. 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, sextant, reticle binoculars, compass, measuring sticks, angle boards, or any other appropriate tools should be used to accurately determine distances/bearings and plot positions of marine mammals.

The operator will ensure that information relating to the activation of an acoustic source and the power output levels employed throughout survey operations is readily available to support the activities of the qualified observers in real time by providing a display screen for acoustic source operations.

> Please review Appendix 2 of the Code carefully. Note that you are required to record the power levels (and timing) of at least one random soft start per swing[1].
>
> Note: the Code is mandatory within the NZ EEZ, as such record keeping should be of a high standard as it may form the basis of compliance or enforcement action by the authorities.

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

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

> It is recommended that observers test the functionality of the datasheets prior to mobilisation and become familiar with their use. In particular, note that macros <u>must</u> be enabled.

All raw datasheets shall be submitted by the qualified observer directly to the Director-General (refer Appendix 5 of the Code for postal and email addresses) within 14 days of a completed MMO/PAM operator 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.

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 Contact details for the Department of Conservation

During the survey, the first point of contact within DOC is Ian Angus (or iangus@doc.govt.nz). 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 following:

1) You wish to provide information to the Marine Species and Threats team, National Office;
2) The name of the MMO/PAM operator, the seismic survey and boat you are currently on;
3) The time and date; and
4) The issue/enquiry they wish to pass on to Ian Angus.

---

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

3.1.1 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 NZOG (
- NZOG to contact EOS and
- EOS to contact DOC).

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

- Team Leader must inform the Party Chief (or nominated NZOG 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 NZOG Staff Geologist (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 NZOG 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 PAM operators);
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 Sound Transmission Loss Modelling, NZOG is required to implement a mitigation measure amended from that outlined in the Code. As outlined in the MMIA (section 2.2.1), the mitigation zone for SOC (without calves) has been increased from 1.0 km to 1.5 km. This MMMP is consistent with the Code and MMIA.

4.1 Dedicated observers (MMOs and PAM operators)

As this is a Level 1 survey, there will be two MMOs and two PAM operators 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 PAM operator on watch at all times while the acoustic source is in the water in the operational area. Observers may stand down from active observational duties while the acoustic source is in the water but inactive for extended periods. Note; an "extended period" does not apply to when the acoustic source may be off during line turns (refer below).

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. 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 on 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 2 and Addenda 3 of this document)

Undertaking work-related tasks, such as completing reporting requirements, while monitoring equipment is allowed during duty watch, but PAM operators 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 PAM operators 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 Mitigation procedures

The proponent will observe the following mitigation practices:

4.2.1 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. For these surveys, the operational area is defined in the MMIA.

4.2.2 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 only. All occasions where activated source volume exceeds notified operational capacity must be fully documented in observer reports. It is the responsibility of the operator to immediately notify the qualified observers if operational capacity is exceeded at any stage.

4.2.3 Sighting conditions

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

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

Beaufort 3

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

BEAUFORT FORCE 3
WIND SPEED: 7-10 KNOTS

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

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

4.2.4 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 4.4.

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 PAM operator 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 PAM operators 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 PAM operator 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, the initial acoustic source activation must not be undertaken at night or during poor sighting conditions unless either:

- MMOs have undertaken observations within 20 nautical miles of the planned start up position for at least the last 2 hours of good sighting conditions preceding proposed operations, and no marine mammals have been detected; or
- Where there have been less than 2 hours of good sighting conditions preceding proposed operations (within 20 nautical miles of the planned start up position), the source may be activated if:
    - PAM monitoring has been conducted for 2 hours immediately preceding proposed operations, and
    - Two MMOs have conducted visual monitoring in the 2 hours immediately preceding proposed operations, 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 PAM operators familiarise themselves with this revision to the Code including the conditions.

4.2.5 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 gun in the array. The MMIA for the survey (section 2.2.1.3) 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 (2,360 in^3) is not to be exceeded during the soft start period."

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

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

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

4.2.6 Line turns

As recommended in the Code (Section 3.8.11) and the MMIA (Section 3.2), the acoustic source will be shut down during line turns. The acoustic source will be reactivated according to pre-start observations (Section 4.1.3 of the Code) and soft start procedures (Section 3.8.10 of the Code). Figure 2 depicts the recommended seismic operations mitigation procedure.

4.3 Species of Concern

The full list of Species of Concern (SOC) as defined by the Code is shown in Addenda 1 below.

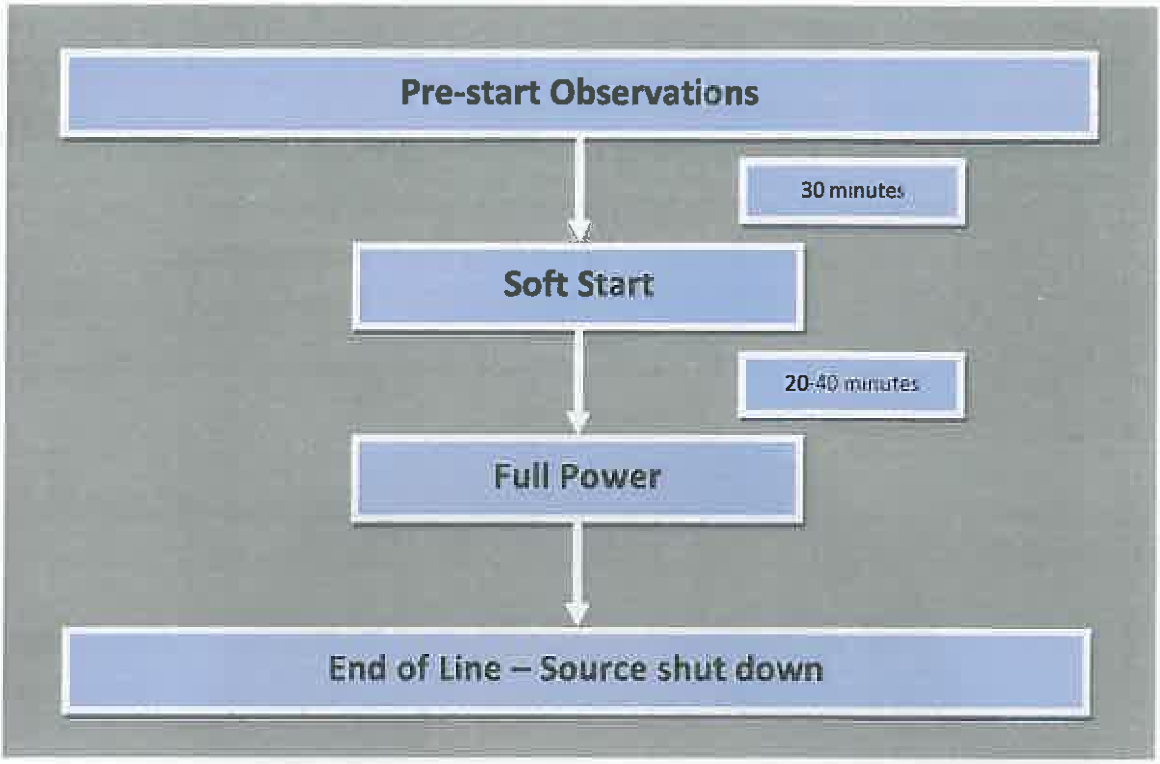


Figure 2: Seismic operations mitigation procedure.

4.4 Mitigation zones

The Code stipulates standard mitigation zones for Level 1 surveys. However, based on assessment of the acoustic source to be used and the nature of the survey area, a revised (i.e. larger) mitigation zone has been specified for SOC (without calves). Details are outlined in the MMIA (section 5.1.2.1) and a summary (MMIA, Section 2.2.1) is provided below:

"The Code of Conduct also requires that Sound Transmission Loss Modelling (STLM) is undertaken when operating a MSS in an AEI to validate the mitigation zones in the Code of Conduct. The STLM is based on the specific configuration of the Waru 2D MSS acoustic array and the environmental conditions (i.e. bathymetry, substrate, water temperature and underlying geology) within the Waru Operational Area. The Code of Conduct states that if Sound Exposure Levels (SEL's) are predicted to exceed 171 dB re 1µPa2.s (behaviour criteria) corresponding to the relevant mitigation zones for Species of Concern or 186 dB re 1µPa2.s (injury criteria) at 200 m, consideration will be given to either extending the radius of the mitigation zones or limiting acoustic source power accordingly.

The STLM is discussed in more detail in Section 5.1.2.1 however the results are briefly summarised here as the mitigation zones for Species of Concern (without calve) have been increased following the STLM so need to be incorporated into the operational procedures for the Waru 2D MSS within this section. STLM showed that compliance was achieved with the Code of Conduct where 100% of SEL's greater than 186 dB re 1µPa2.s were within 200 m of the acoustic source, however 95% of SEL's were below 171 dB re 1µPa2.s at 1.1 km and 100% were below at 1.5 km. Therefore, due to SEL's of 171 dB re 1µPa2.s being greater than 1 km from the acoustic source, the mitigation zone for Species of Concern will be increased from 1.0 km to 1.5 km for the Waru 2D MSS throughout the entire Waru Operational Area. The increased mitigation zone has been incorporated throughout this MMIA for the relevant mitigation measures and compliance with the Code of Conduct.

The mitigation zone for Species of Concern with calve present in the Code of Conduct will remain at 1.5 km, as the STLM showed this distance is compliant with the behaviour criteria requirements."

Therefore the mitigation zones for this survey are (Figure 3):

1) 1.5 km from the centre of the acoustic source for SOC **with** calves;
2) 1.5 km from the centre of the acoustic source for SOC **without** calves; and
3) 200 m from the centre of the acoustic source for all other marine mammals.

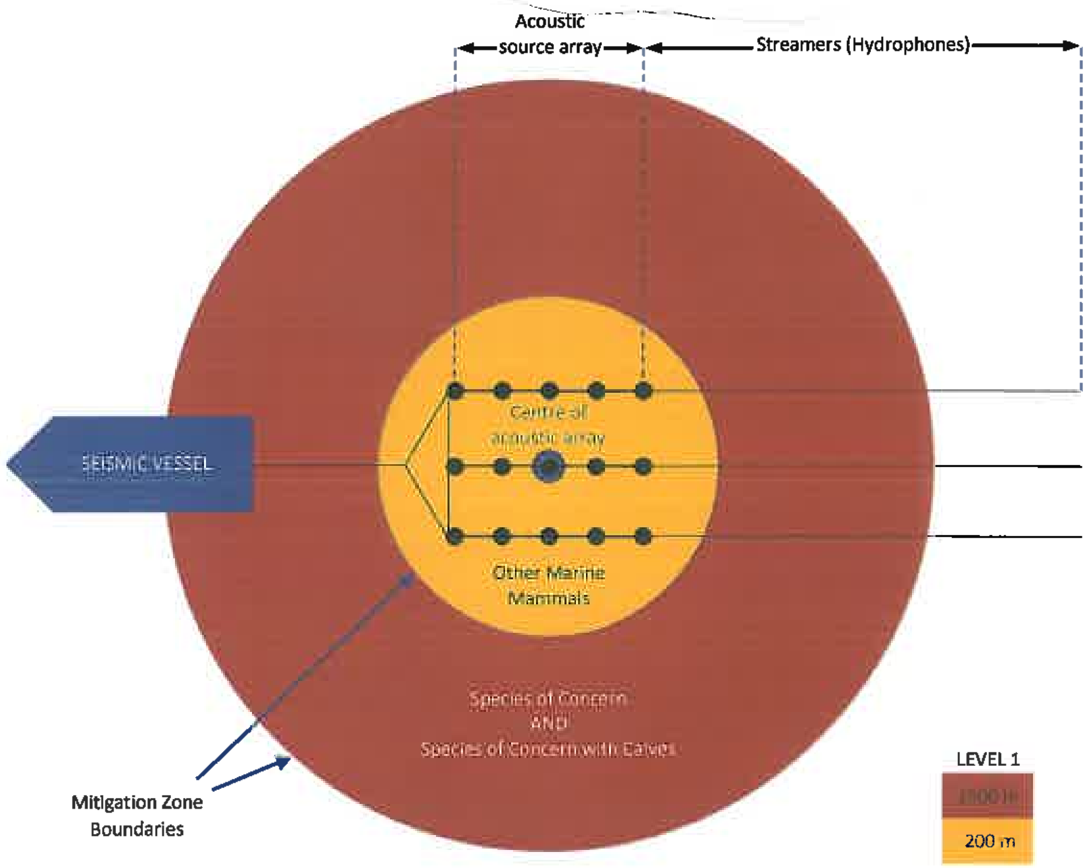


Figure 3: Mitigation Zone Boundaries for the Waru 2D Marine Seismic Survey.

NOTE: The mitigation zone for SOC is larger than that identified in the Code and MMOs must be familiar with this.

4.4.1 PAM and calves

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

PAM operators must be familiar with this requirement.

4.5 Mitigation actions

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

4.5.1 Species of Concern with calves

If during pre-start observations or when the acoustic source is active (including soft starts) the observer (MMO or PAM operator) detects at least one cetacean SOC with a calf within 1.5 km of the source, start up will be delayed, or the source will be shut down and not reactivated until:

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

In regard to cetacean SOC with a calf, note that the requirements above apply to the entire group containing that calf. An explanatory note from DOC[2]: " *Yes, whole group has to be seen to move beyond zone, or not be seen for 30 mins*", and "*The intent of this provision is that since a group of marine mammals containing one calf has potential to contain more (and at distance it may be hard to follow movement of the cow/calf pair), the same precaution should apply to all the individuals*".

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans[3] (<300 m), any such bioacoustic detections will require an immediate shutdown of an active survey or will delay the start of operations, regardless of signal strength or whether distance or bearing from the acoustic source has been determined. Shutdown of an activated acoustic source will not be required if visual observations by a qualified MMO confirm that the acoustic detection was of a species falling into the category of 'Other Marine Mammals'.

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

4.5.2 Species of Concern without calves

If during pre-start observations or when the acoustic source is active (including soft starts) the observer (MMO or PAM operator) detects a SOC (without calves) within 1.5 km of the source, start up will be delayed, or the source will be shut down and not reactivated until:

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

It is recommended that due to the range limitations of PAM, all acoustic detections of cetaceans using ultra high frequency vocalisations (e.g. Maui'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

[2] Email to BPM from Mr Tara Ross-Watt, DOC Senior Adviser - International and Marine; 17 December 2012.
[3] 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.

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.

4.5.3 Other Marine Mammals

If, during pre-start observations prior to initiation of a Level 1 acoustic source soft start, a qualified observer detects a marine mammal within 200 m of the source, start up will be delayed until:

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

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

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

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

4.5.4 Mitigation posters and summary

Refer to Addenda 2 of this MMMP for posters detailing mitigation action procedures.

5. Further Mitigation Measures

The following additional 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 NZOG and DOC.

1) **Autopsy of any stranded marine mammals during the survey**

   If any marine mammals are stranded or washed ashore during the survey inshore of the Waru Operational Area from New Plymouth south to the Kapiti coastline, NZOG 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. MMOs should report any dead marine mammals seen in the operational area to DOC immediately.

2) **Notification of any Maui's dolphin sighting**

   If a Maui's dolphin is observed at any stage during the survey or while the *Aquila Explorer* is mobilising to and from the Waru Operational Area, DOC National Office (Ian Angus: and DOC Taranaki Area Office (Callum Lilley: will be notified immediately. If neither are available, please call 0800DOCHOT to report the sighting.

   DOC are keen to help with further research of this endangered species and if a sighting was to occur, depending on the location DOC may mobilise either a fixed-wing plane for verification and/or a vessel to try and obtain a biopsy sample.

3) MMOs to maintain observations when outside the operational area

The *Aquila Explorer* will travel to the Waru Operational Area from its previous seismic survey. On transit to the Waru Operational Area, an 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.

Any marine mammal observations outside the Waru Operational Area will be recorded in the 'Off Survey' forms developed by DOC. Any Maui's dolphins observed will be reported immediately to DOC as per item 2 above.

6. Notifications to DOC

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

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 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 and state the information as outline in Section 3.1.

In the instance of a Maui's/Hector's dolphin sighting please contact Callum Lilley from the Taranaki office of DOC on directly (after notifying the Party Chief) rather than following the communication protocol below.

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 confirmed sighting of Maui's/Hector's dolphin	Immediate	This applies to both in transit and in the survey operational area
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 4.2.2 of this MMMP.
Observation of any dead marine mammals seen in the operational area	Immediate	MMOs should report to DOC immediately 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)

Addenda 1: Species of Concern as defined in the Code

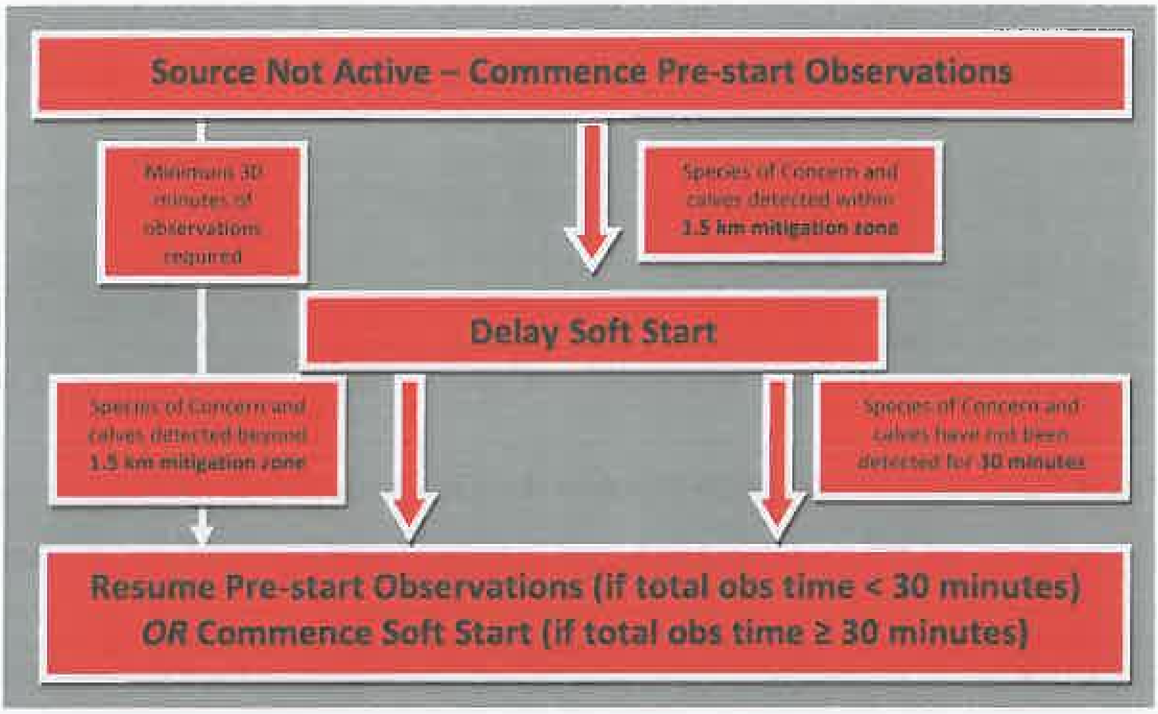
Common name	Latin name
Andrew's beaked whale	*Mesoplodon bowdoini*
Antarctic minke whale	*Balaenoptera bonarensis*
Arnoux's beaked whale	*Berardius arnuxii*
Blainville's beaked whale	*Mesoplodon densirostris*
Blue whale	*Balaenoptera musculus*
Bottlenose dolphin	*Tursiops truncatus*
Bryde's whale	*Balaenoptera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

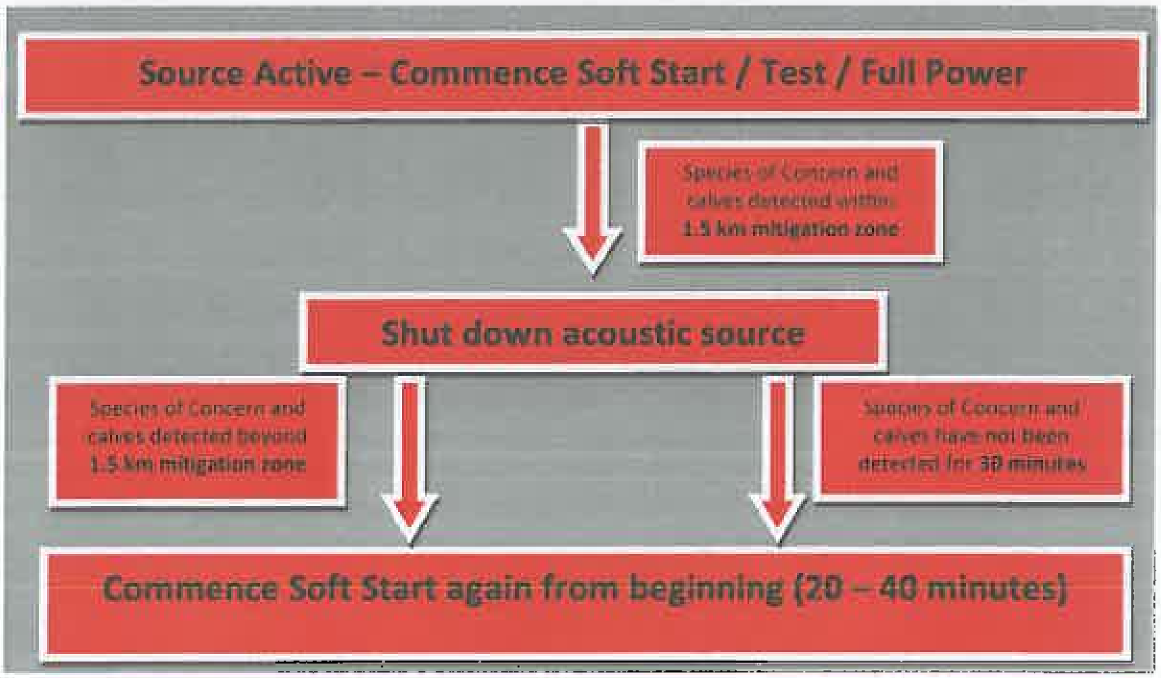
Southern Bottlenose whale	*Hyperoodon planifrons*
Southern right whale	*Eubalaena australis*
Southern right whale dolphin	*Lissodelphis peronii*
Sperm whale	*Physeter macrocephalus*
Strap-toothed whale	*Mesoplodon layardii*
True's beaked whale	*Mesoplodon mirus*

Addenda 2: Mitigation Procedures – Good Sighting Conditions (poster format)

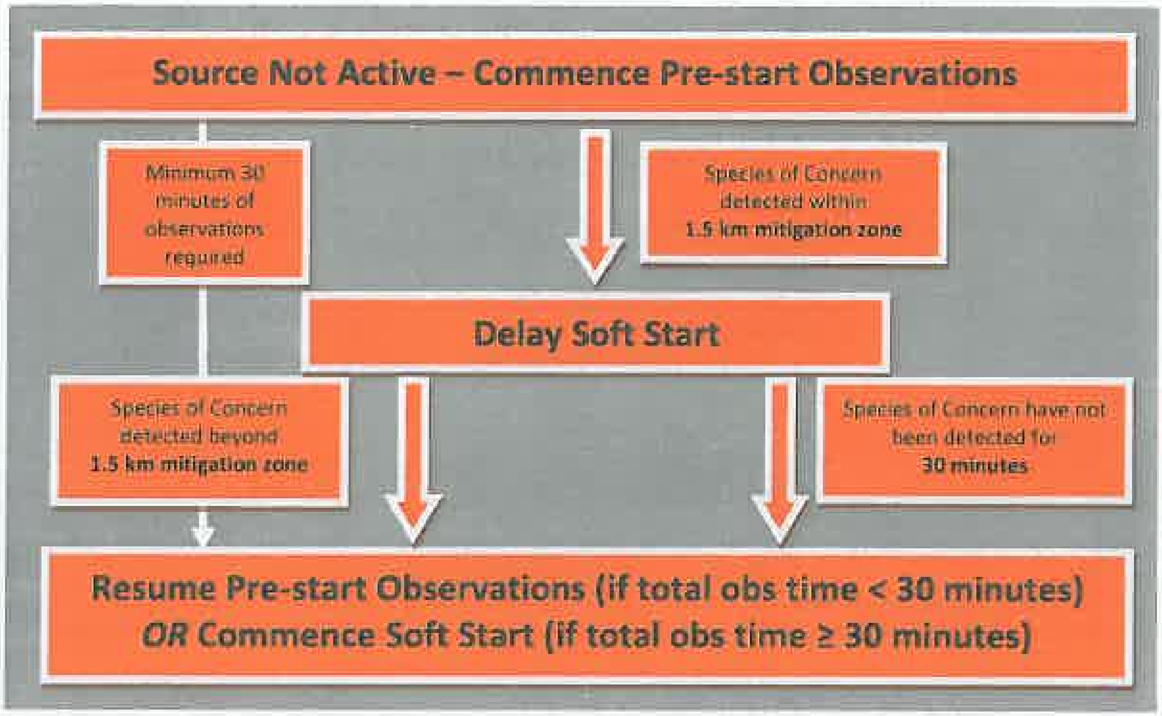
The following posters depict mitigation procedures. It is recommended they be posted in the instrument room, the PAM station and on the bridge. Operational flowcharts are also found in Appendix 4 of the Code.

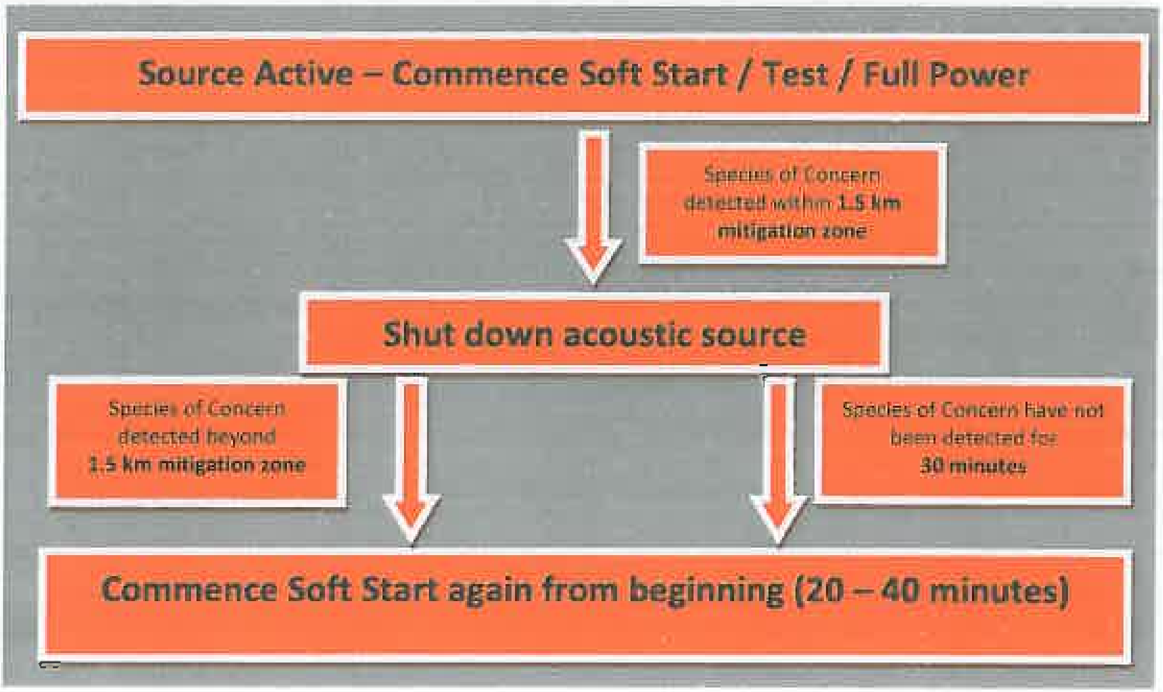
Species of Concern with Calves within 1.5 km of Acoustic Source





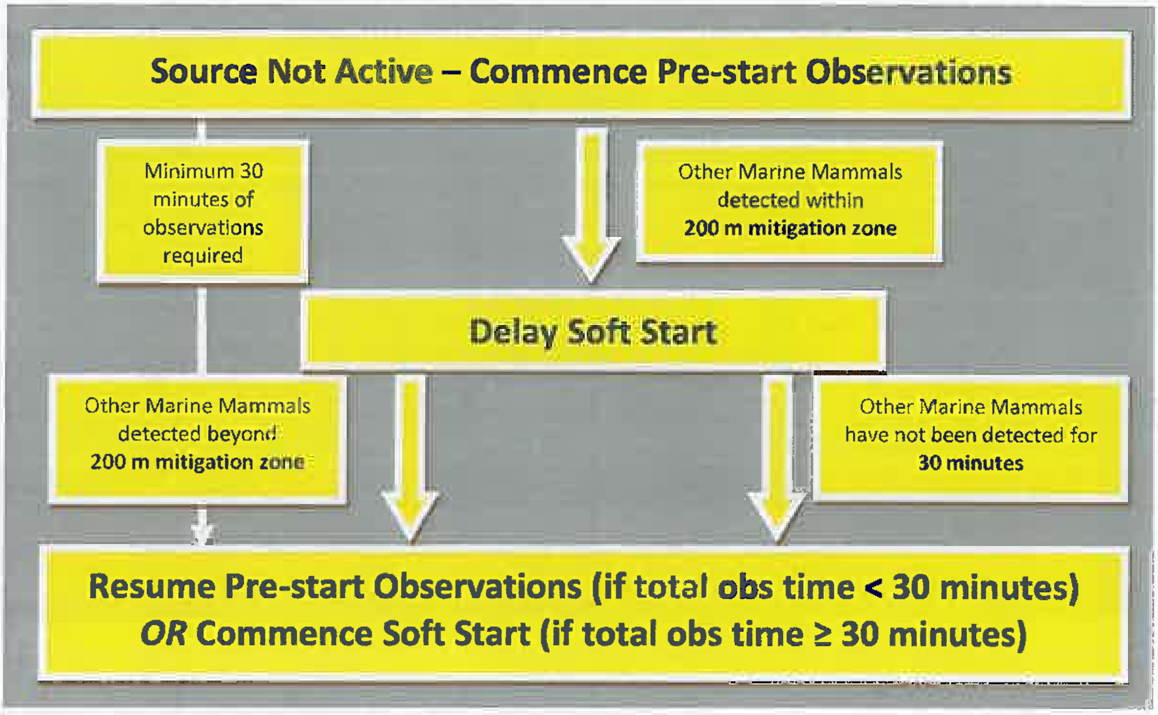
Species of Concern (no Calves) within 1.5 km of Acoustic Source





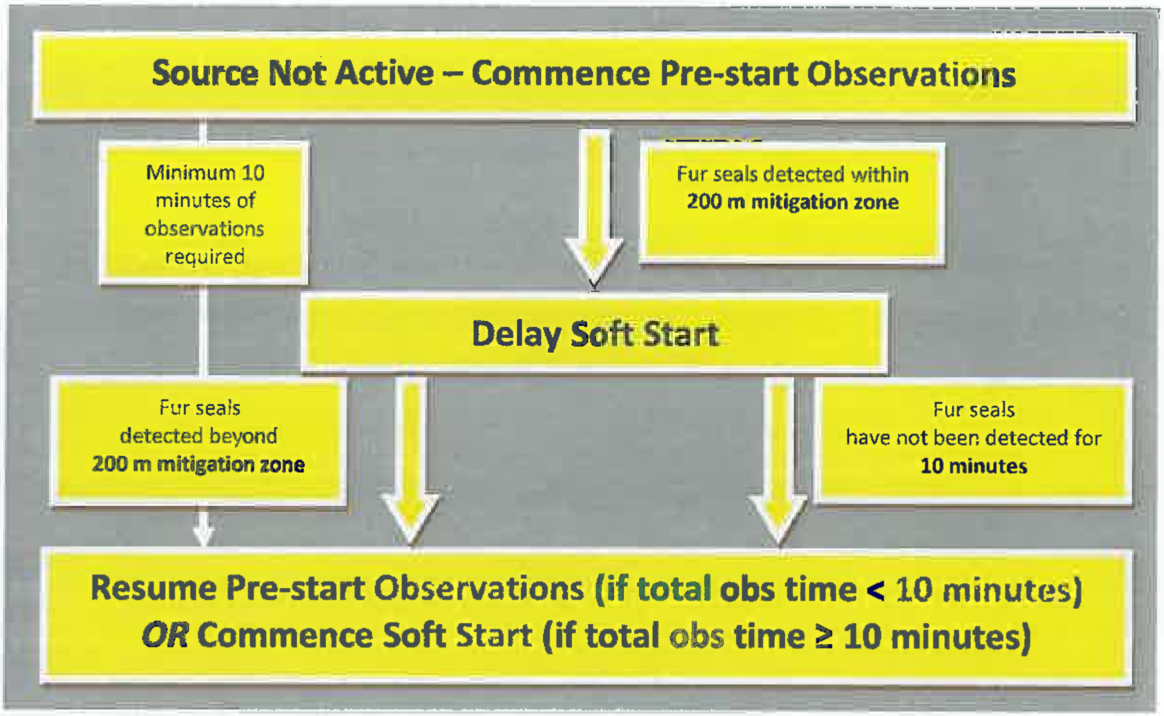
Other Marine Mammals within 200 m of Acoustic Source

(excluding fur seals – see below)



BLUE PLANET MARINE

Fur seals within 200 m of Acoustic Source



BLUE PLANET MARINE

Addenda 3: Recommended Communication Protocols (poster format)

Note: Seismic control room to immediately notify observers (MMO and PAM) of any changes in the status of seismic guns.

Normal Operations - No Marine Mammal Sighting/Detection

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

↓

Prior to soft start, seismic call observers for ALL CLEAR

↓

Seismic notify observers time of soft start

↓

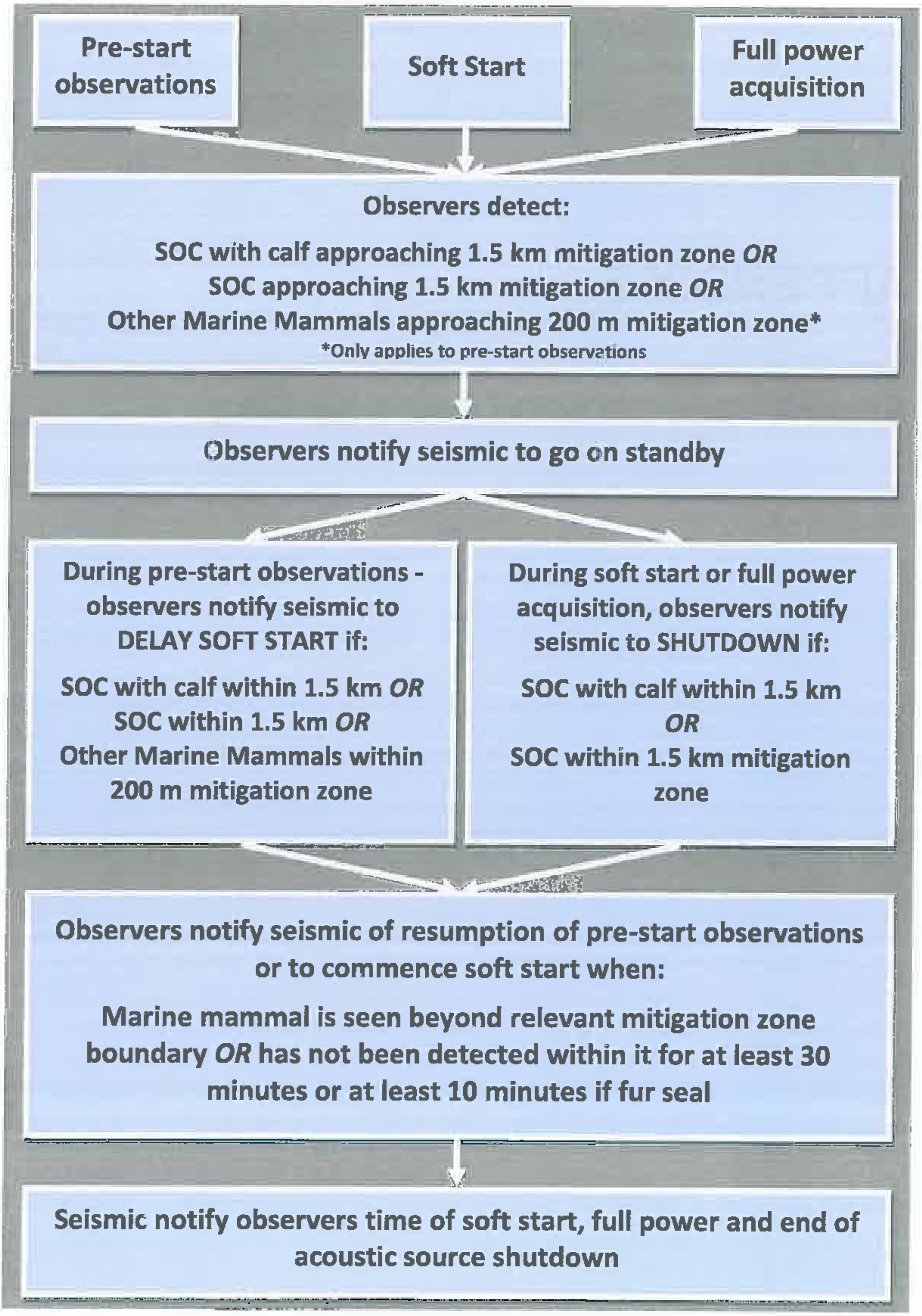
Seismic call observers to confirm time of full power

↓

Seismic notify observers time of end of acoustic source shutdown

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

Delayed Soft Start or Shutdown – Marine Mammal Sighting/Detection



APPENDIX 5

Sound Transmission Loss Modelling

Curtin University

Centre for Marine Science and Technology

Sound Transmission Loss Modelling for the Waru 2D Seismic Survey

Prepared for:

NZOG Limited

Prepared by: Matthew Koessler and Alec Duncan

PROJECT CMST 1285
REPORT 2014-9

27th February 2014

Abstract

This report describes acoustic propagation modelling that was carried out to predict received sound exposure levels from the Waru 2D seismic survey. The modelling method used to produce these results accurately deals with both the horizontal and vertical directionality of the airgun array, and with variations in water depth and seabed properties.

Modelling predicted that the maximum sound exposure levels produced by the Aquila Explorer 2360 cui array operating within the 2D survey area will be below 186 dB re 1 $\mu Pa^2.s$ at a range of 200m. Some receiver azimuths may produce levels above 171 dB re 1 $\mu Pa^2.s$ at a range of 1km whereas all levels are predicted to be below 171 dB re 1 $\mu Pa^2.s$ at a range of 1.5km. Therefore the current configuration Aquila Explorer 2360 cui array operating within the shallow water depths of the Waru 2D survey region may only partially meet the sound exposure level requirements of the New Zealand Department of Conservation 2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations. At a range of just over 100m, 95% of received sound exposure levels were predicted to be below 186 dB re 1 $\mu Pa^2.s$, and at a range of just over 1.1km, 95% of received sound exposure levels were predicted to be below 171 dB re 1 $\mu Pa^2.s$.

Contents

List of Figures

1 Introduction

This report describes acoustic propagation modelling which was carried out to predict received sound exposure levels from a 2D seismic survey proposed by New Zealand Oil and Gas Ltd. (NZOG). Modelling is conducted in order to establish whether a given survey meets the sound exposure level requirements of the New Zealand Department of Conservation 2012 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 $\mu Pa^2.s$ at a range of 200m from the source, or 171 dB re 1 $\mu Pa^2.s$ at ranges of 1km and 1.5km.

The survey is located in the South Taranaki Bight region, just south of Cape Egmont, New Zealand, and is shown in Figure 1. The detailed bathymetry (CANZ 2008) is plotted in Figure 2 with the survey area overlaid. This plot shows that the water depth ranges from about 40 m in the northeast to about 100m in the southwest of the survey area.

Section 2 describes the methods used to carry out the modelling and the results are presented in Section 3. Conclusions are given in Section 4.

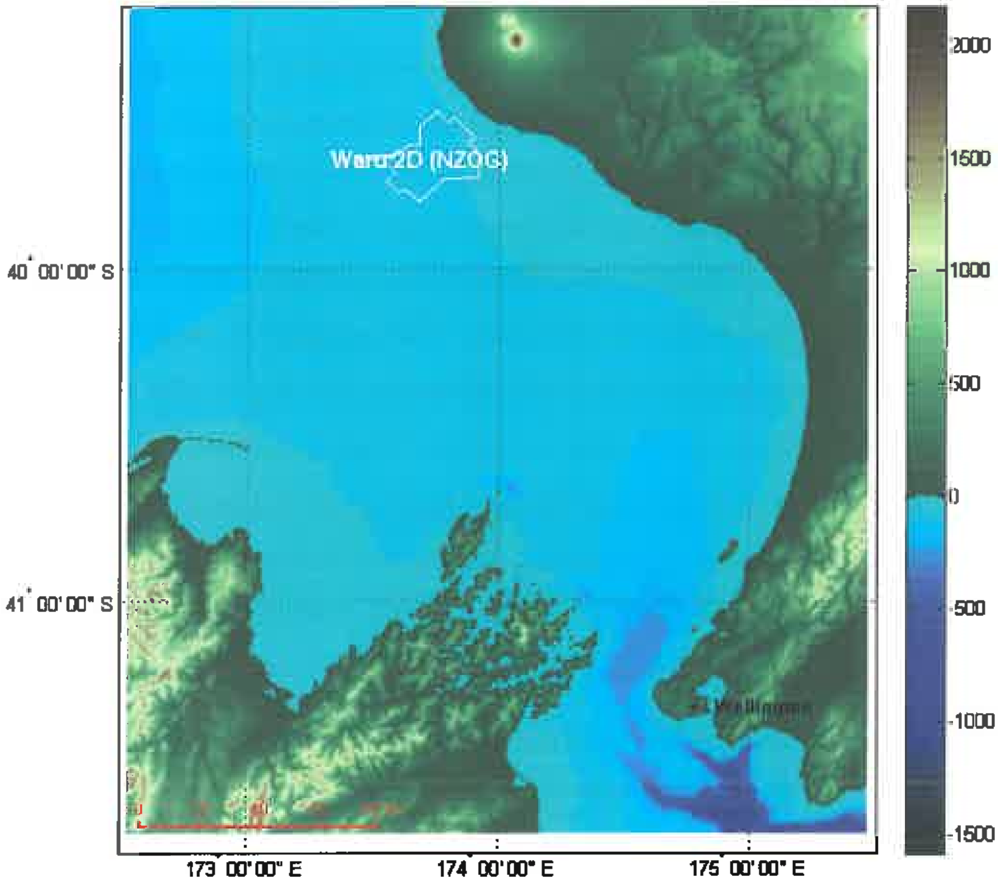


Figure 1. A regional map of the south Taranaki Bight New Zealand showing the survey area, the bathymetry is from the NIWA database.

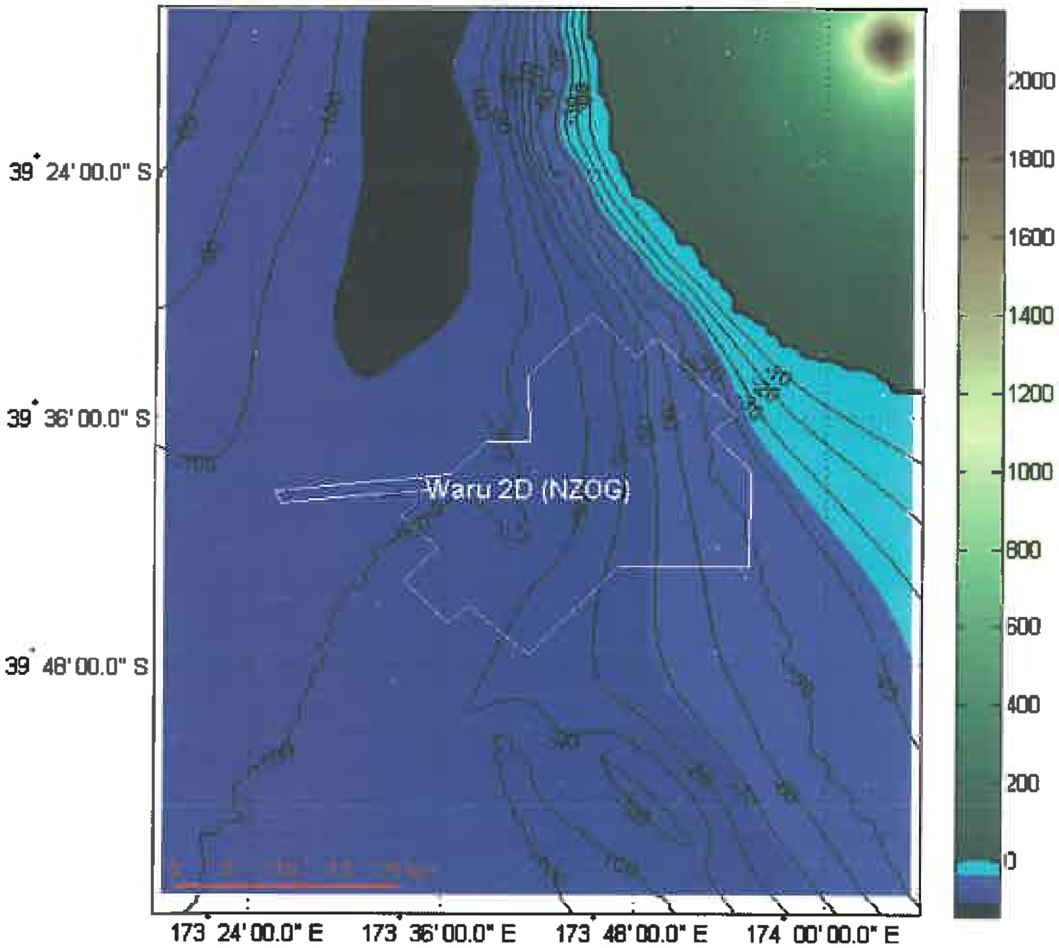


Figure 2. Survey bounding polygon (white) showing modelled source locations and bathymetry contours, the bathymetry is from the NIWA database

2 Methods

2.1 Source modelling

The airgun array proposed for this survey is the Aquila Explorer 2360 cubic inch array shown in Figure 3.

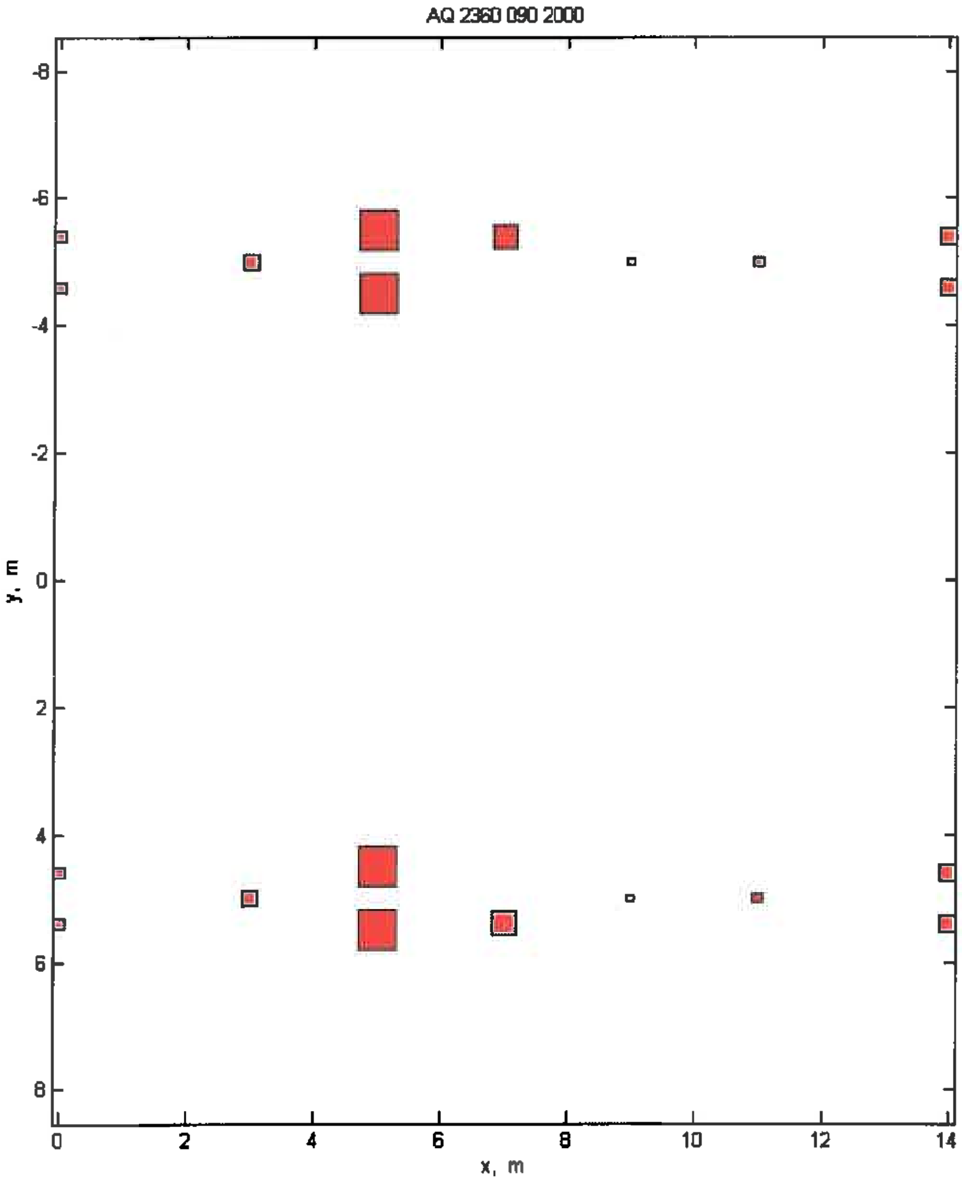


Figure 3. Plan view of the Aquila Explorer 2360cui array. Array elements are shown much larger than actual size but are scaled proportional to the cube root of their volume.

2.1.1 Modelling and calibration methods

Acoustic signals required for this work were synthesised using CMST's numerical model for airgun arrays. The procedure implemented for each individual source element is based on the bubble oscillation model described in Johnson (1994) with the following modifications:

- An additional damping factor has been added to obtain a rate of decay for the bubble oscillation consistent with measured data;
- The zero rise time for the initial pressure pulse predicted by the Johnson model has been replaced by a finite rise time chosen to give the best match between the high frequency roll-off of modelled and measured signal spectra;
- For the coupled-element model used in this work, the ambient pressure has been modified to include the acoustic pressure from the other guns in the array and from the surface ghosts of all the guns. Including this coupling gives a better match between the modelled signal and example waveforms provided by seismic contractors, but only has a minor influence on the spectrum of this signal and hence on the modelled received levels.

The model is subjected to two types of calibration:

- The first is historical and was part of the development of the model. It involved the tuning of basic adjustable model parameters (damping factor and rise time) to obtain the best match between modelled and experimentally measured signals, the latter obtained during sea trials with CMST's 20 in^3 air gun. These parameters have also been checked against several waveforms from larger guns obtained from the literature.
- The second form of calibration is carried out each time a new array-geometry is modelled, the results of which are presented below. Here, the modelled gun signals' amplitudes are scaled to match the signal energy for a far-field waveform for the entire array computed for the nadir direction (including ghost) to that of a sample waveform provided by the Client's seismic contractor. When performing this comparison the modelled waveform is subjected to filtering similar to that used by the seismic contractor in generating their sample, or additional filtering is

applied to both data sets to emphasise a section of the bandwidth of the supplied data which CMST regards as being most reliable.

Beam patterns for the calibrated array were built up one azimuth at a time as follows:

- The distances from each gun to a point in the far-field along the required azimuth were calculated. (The far-field is the region sufficiently far from the array that the array can be considered a point source);
- The corresponding time delays were calculated by dividing by the sound speed;
- Computed signals for each gun were delayed by the appropriate time, and then these delayed signals were summed over the guns;
- The energy spectral density of the resulting time domain waveform was then calculated via a Fourier transform;
- During this procedure care was taken to ensure that the resulting spectrum was scaled correctly so that the results were in source energy spectral density units: dB re 1 $\mu Pa^2 s/Hz$ @ 1m.

2.1.2 Source modelling results

Figure 4 shows a comparison between the example waveform and spectrum 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 excellent.

The example waveform provided was for an array depth of 9 m and was used to calibrate the CMST airgun array model; however the planned source depth for the survey is 8 m. As such the subsequent propagation modelling detailed in section 2.2 of this report was carried out at a source depth of 8m.

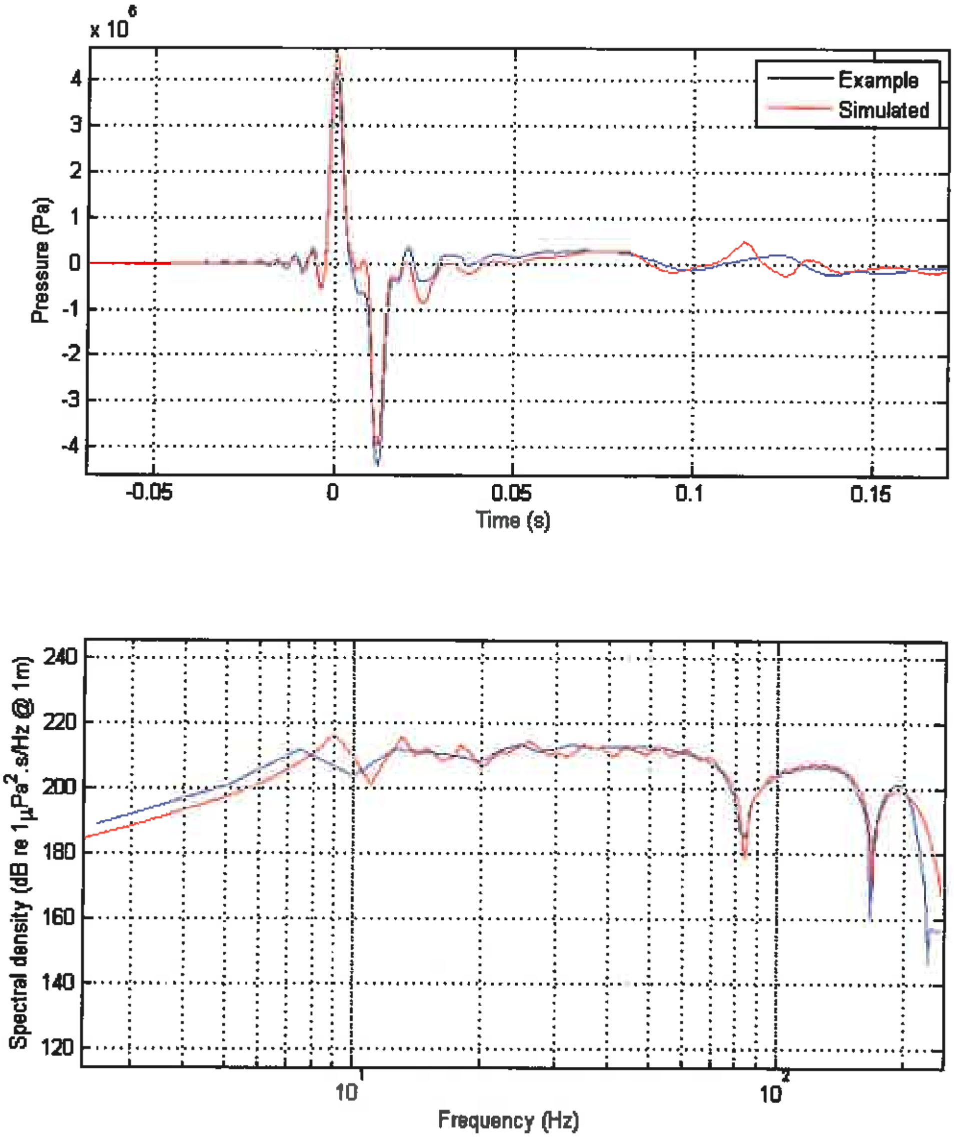


Figure 4. Comparison between the waveforms (top) and spectra (bottom) of the example signal for the vertically downward direction provided by the client (blue) and the signal produced by CMST's airgun array model (red).

Vertical and horizontal cross-sections through the frequency dependent beam pattern of the array are shown in Figure 5. 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 the bulk of the high frequency energy is radiated in the cross-line direction. This is typically the case for seismic airgun arrays but is particularly apparent for this particular array as a result of it consisting of only two subarrays.

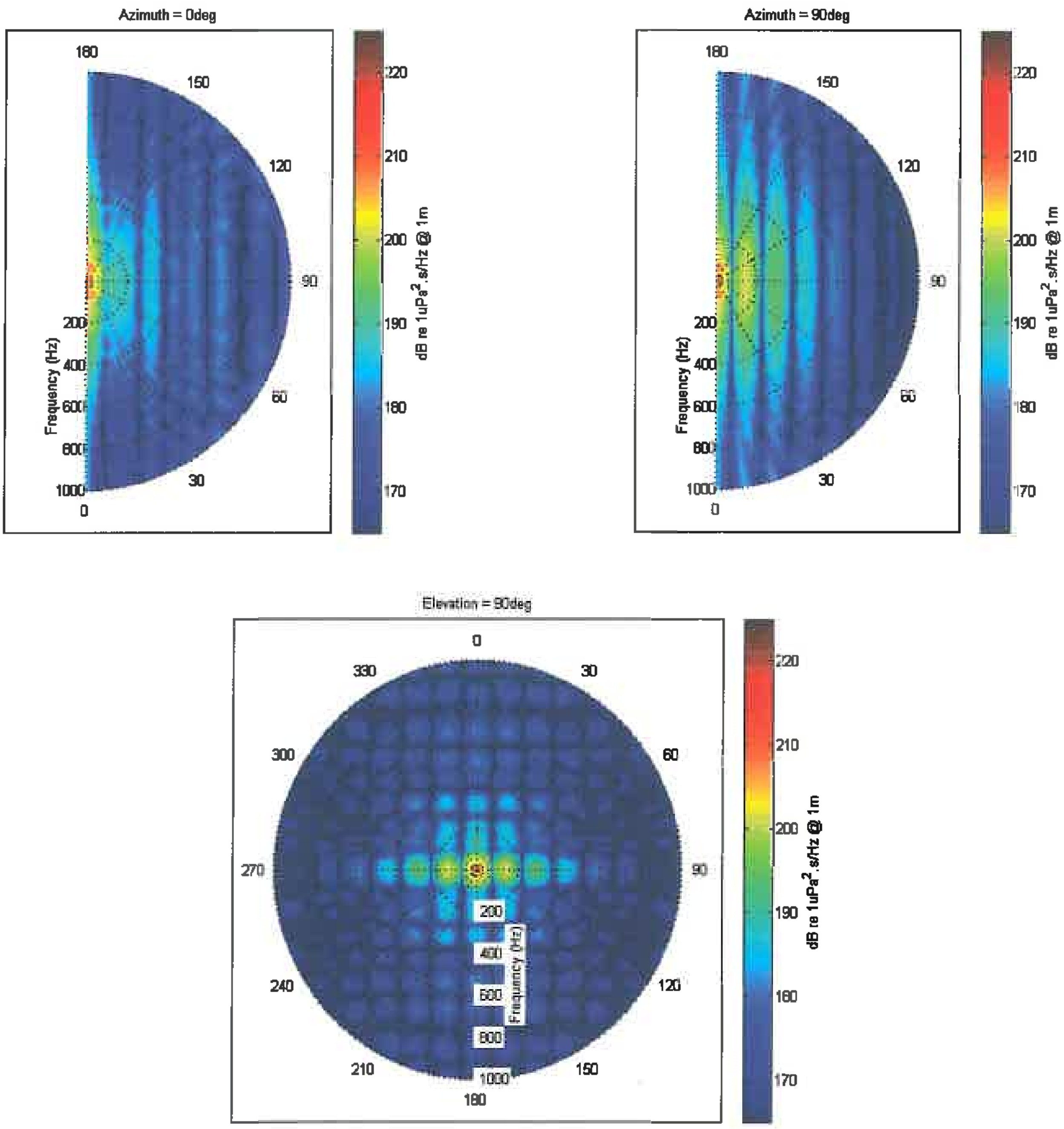


Figure 5. Array far-field beam patterns as a function of orientation and frequency (radial coordinate). The top two plots are for the vertical plane for the in-line direction (left) and cross-line direction (right). Zero elevation angle corresponds to vertically downwards. The bottom plot is for the horizontal plane with 0 degrees azimuth corresponding to the in-line direction.

2.2 Propagation modelling

Source locations & bathymetry

The bathymetry data shown in Figure 6 was obtained from the NIWA New Zealand gridded elevation and bathymetry dataset (CANZ 2008). For each source location shown in Figure 6 the source was placed at a water depth of 8 m. The ocean water depth at each source location is summarised below in Table 1.

Table 1. Source number and the corresponding ocean depth at the source location

Source Number	Ocean Bottom Depth (m)
S1	40
S2	50
S3	60
S4	70
S5	80
S6	90
S7	100
S8	103

These bathymetries were chosen to model various scenarios where the greatest amount of sound energy would propagate in the ocean.

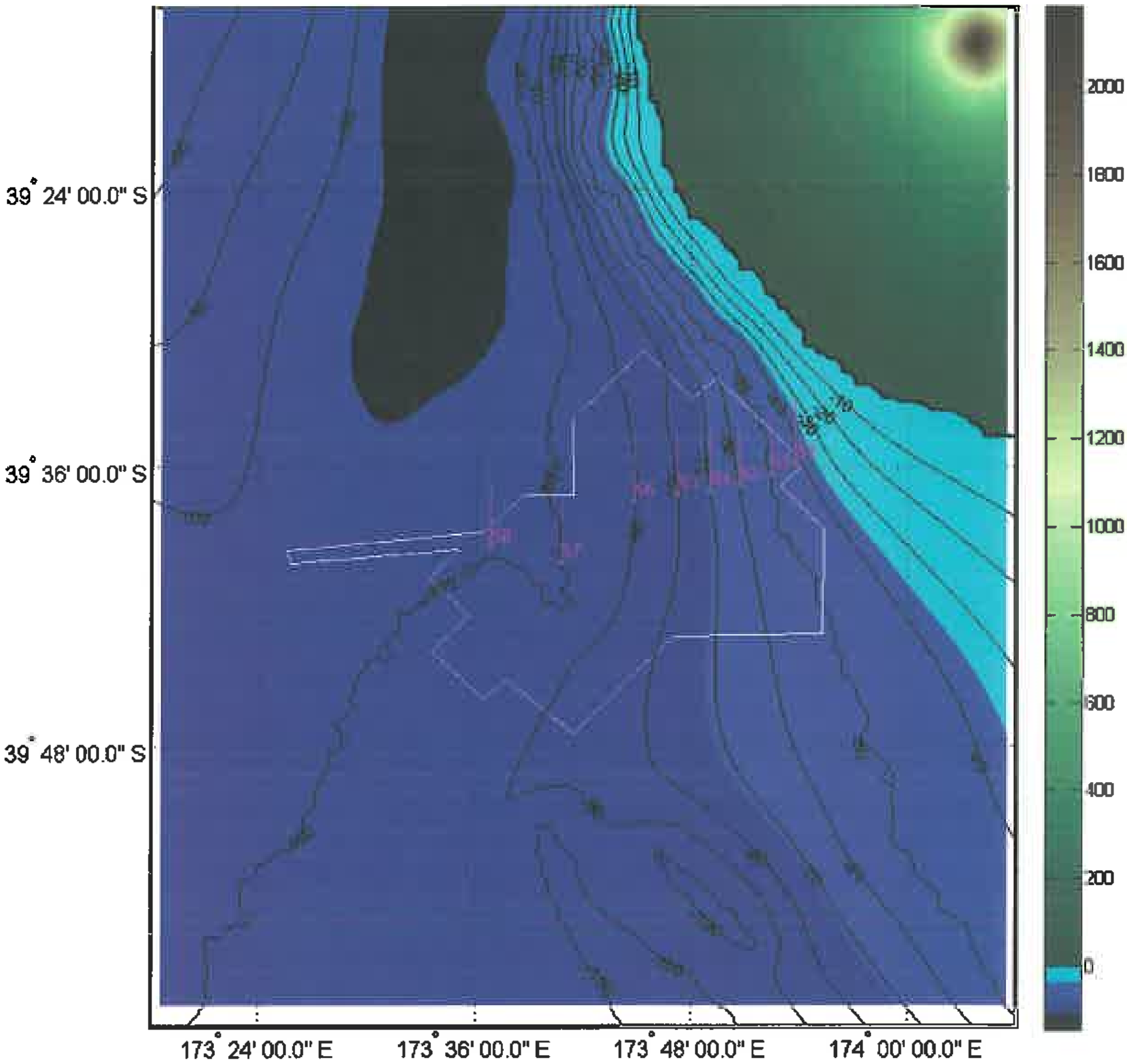


Figure 6. Source locations in over various water depths encountered in the survey area.

Water-column properties

A representative sound velocity profile for the summer months of the southern hemisphere was used to obtain the best estimate of the environmental conditions at the time of the proposed survey. A sound velocity profile was obtained from the nearest grid point of the World Ocean Atlas (NOAA, 2005); the profile is shown in Figure 7. The profile shows a mixed layer of almost constant sound speed down to a depth of about 20 m. Below 20 m there is a reduction of sound speed to 50 m.

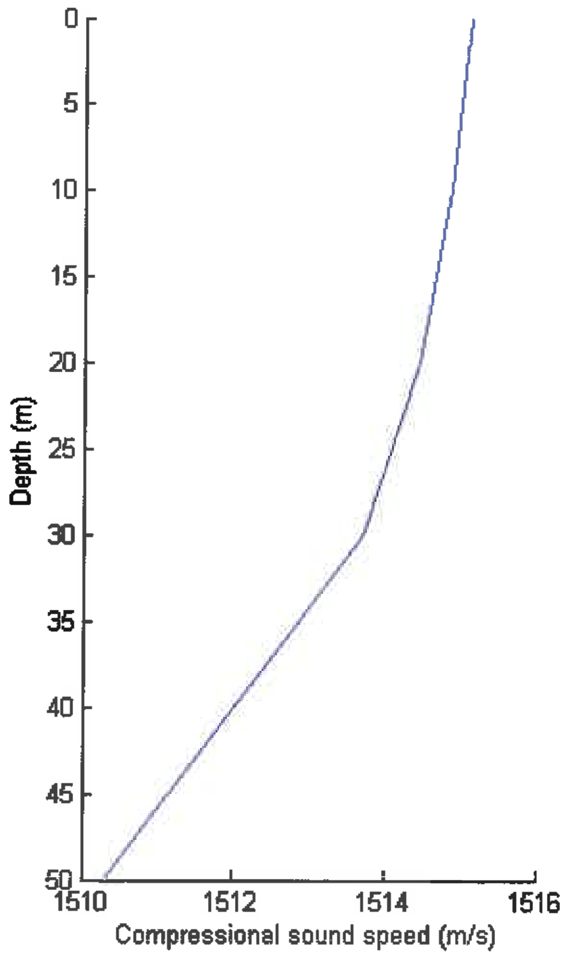


Figure 7. The water column sound velocity profile used for propagation modelling.

Seabed Properties

The seabed geoacoustic model was based on information provided by NZOG and peer-reviewed literature. A report was provided which presented seafloor data collected by FUGRO BTW Ltd. ("Report on Site Survey Kaupokoni," 2010) near the proposed Waru 2D seismic survey location. These data included five seabed samples, sub-bottom profiler data, side-scan sonar data, and single beam echo sounder data. The assumed seabed properties are given in Table 2 and were obtained by collectively considering information in the above.

Lionel Carter (1975) categorises the bottom type of the near shore region as being composed of sandy sediments. The seabed samples collected by FUGRO BTW Ltd. were found to be composed of fine sand and silt sediments with varying amounts of shells and shell fragments. Therefore, the seafloor sediments near the source location were modelled as being composed of fine sand and some silt. The geoacoustic parameters for this type of sediment were taken from Hamilton (1980).

The sub-bottom profiles from the FUGRO BTW Ltd. bathymetry survey indicated a sediment package at least 150m thick ("Report on Site Survey Kaupokoni," 2010). For thick layers of seafloor sediments, compaction and porosity reduction can change the sound propagation parameters within a layer (Jensen, Kuperman, Porter, & Schmidt, 1994). As such, a sound speed gradient was included between the top and the bottom of the sediment layer (Hamilton, 1979). This gradient linearly increased compressional wave speed with depth as seen in Table 2.

Table 2: Seabed acoustic data used in propagation modelling.

Layer	Thickness (m)	Density ($kg.m^{-3}$)	Compressional wave speed ($m.s^{-1}$)	Compressional wave attenuation (dB per wavelength)	Shear Wave Speed ($m.s^{-1}$)	Shear wave attenuation (dB per wavelength)
Sand Silt Layer	150	1747	1646	0.8	0	0
		1747	1830		0	0
Sand Silt Half Space	N/A	1747	1830	0.8	0	0

Choice of propagation modelling codes

The relatively flat seabed within the source region of the survey area and the short ranges required for modelling made it possible to use the range independent propagation modelling code SCOOTER (Porter 2007) for this work. SCOOTER is a wavenumber integration code, which is stable, reliable, and can deal with arbitrarily complicated seabed layering. It cannot, however, deal with changes of water depth with range, but that is unimportant in this particular application.

2.3 Sound exposure level (SEL) calculations

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 2 Hz frequency steps from 2 Hz to 1000 Hz for a source depth corresponding to the depth of the airgun array (8 m). 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.

    d. The sound exposure level (SEL) at the receiver was calculated by squaring and integrating the pressure signal.

3 Results

Plots of predicted maximum received sound exposure level at any depth as a function of range and azimuth from the source are given in Figure 8 and Figure 9 for maximum ranges of 500m and 2.5km respectively. S1 is source location for these SEL plots and it is the location with the shallowest water depth. The strong horizontal plane directionality is due to the directionality of the airgun array, which produces its highest levels in the cross-line direction.

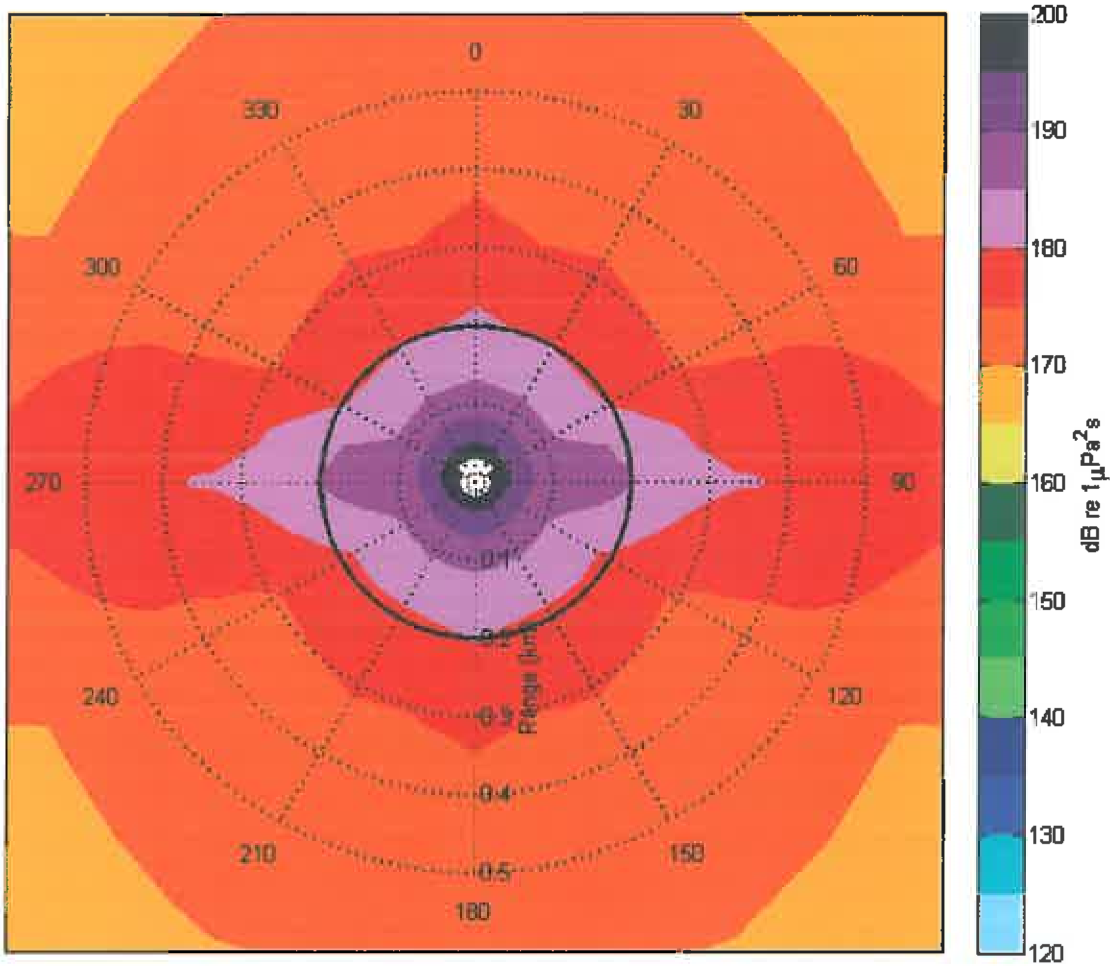


Figure 8. Predicted maximum received SEL at any depth as a function of azimuth and range from the source to a maximum range of 500m. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to the 200m mitigation range.

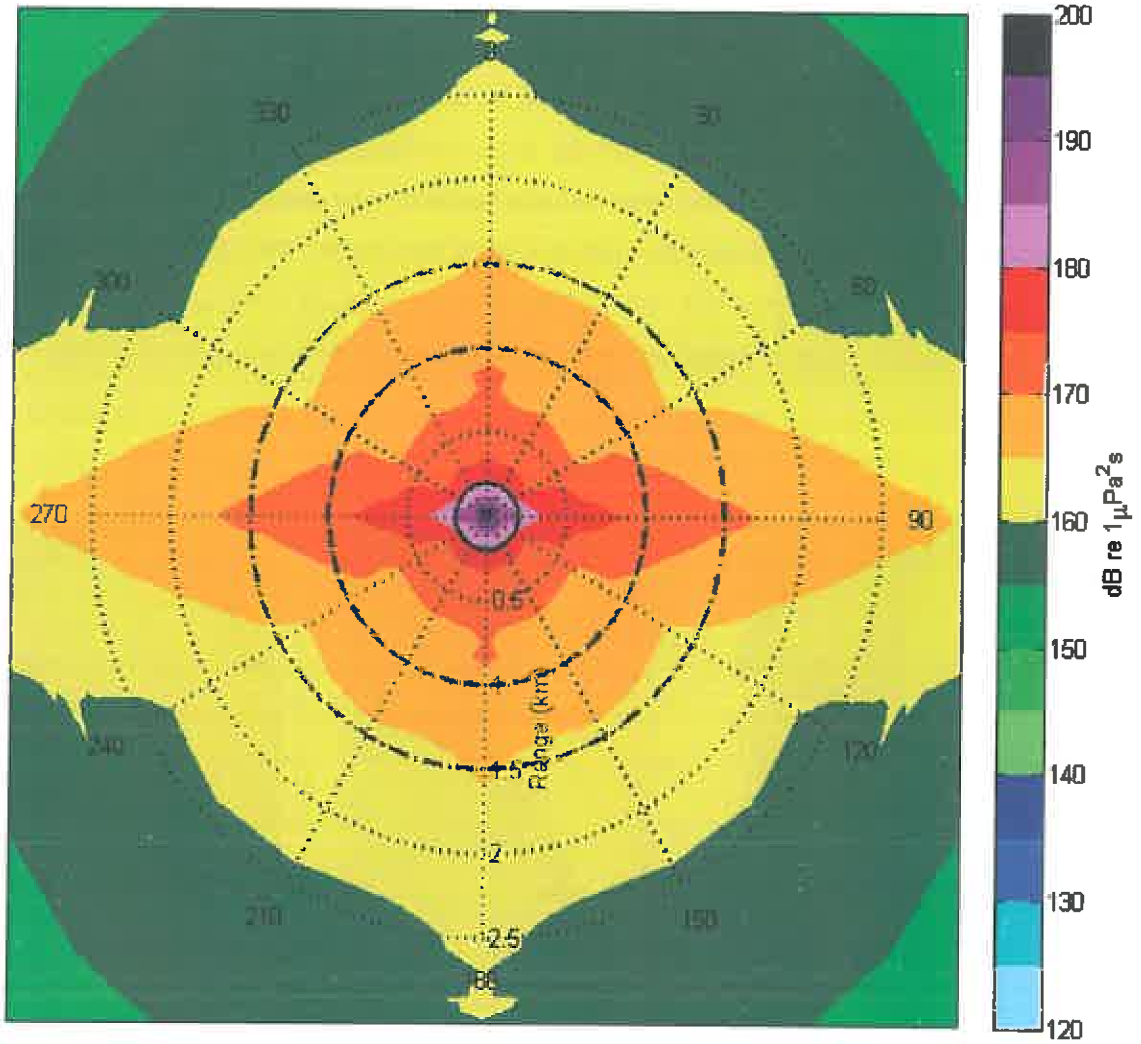


Figure 9. Predicted maximum received SEL at any depth as a function of azimuth and range from the source to a maximum range of 3km. An azimuth of 0° (up) corresponds to the in-line direction. The thick black circle corresponds to mitigation ranges of 200m (solid), 1km (dash), and 1.5km (dash-dot).

Three cross-sectional slices of SEL for the S1 source location are presented in Figure 10. These SEL cross-sections show that the levels produced by the array are reasonably constant through most of the water column but tend to be greatest near the ocean bottom where energy reflected from the seabed is most significant. The right panel of Figure 10 show that the maximum SEL that is expected to be received in the water column occurs in the cross-line receiver direction, which is a consequence of the airgun array directionality.

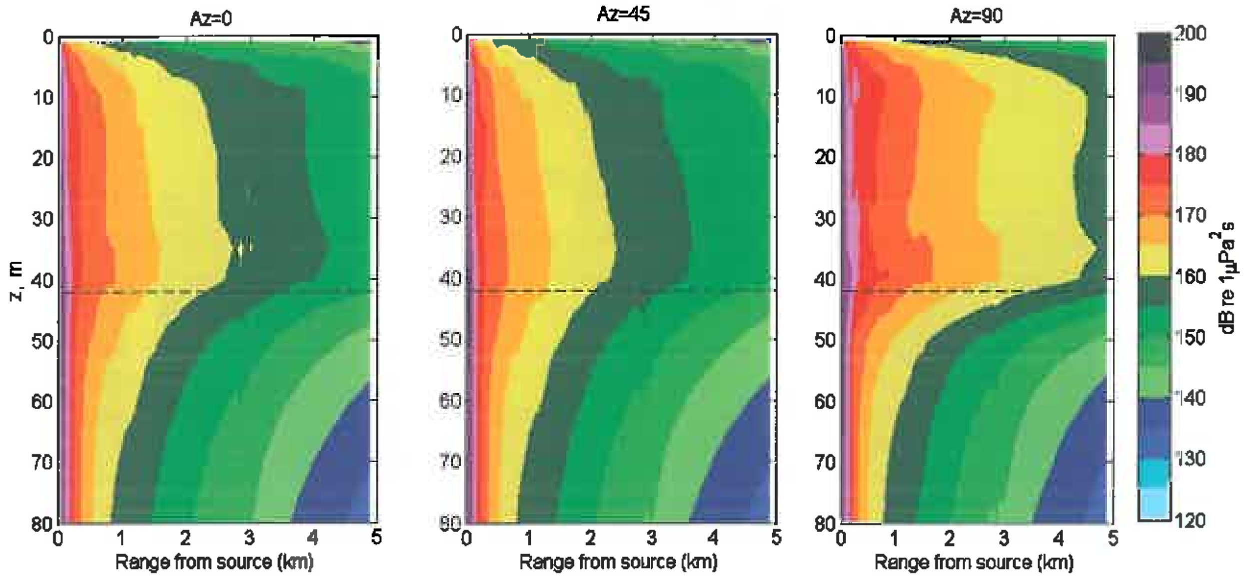


Figure 10. Slices of SEL that vary with depth and range for 3 different azimuths. The black dash line represents the seafloor depth at the source location. *Left:* 0° azimuth (in-line) SEL cross-section. *Centre:* 45° azimuth SEL cross-section. *Right*: 90° azimuth (cross-line) SEL cross-section.

Figure 11 plots the percentage of received shots below standard thresholds as a function of range from a source at the S1 location. This plot shows that 95% of shots are predicted to be below 186 dB re 1 μPa^2.s at a range of just over 100m, and below 171 dB re 1 μPa^2.s at a range of just over 1km.

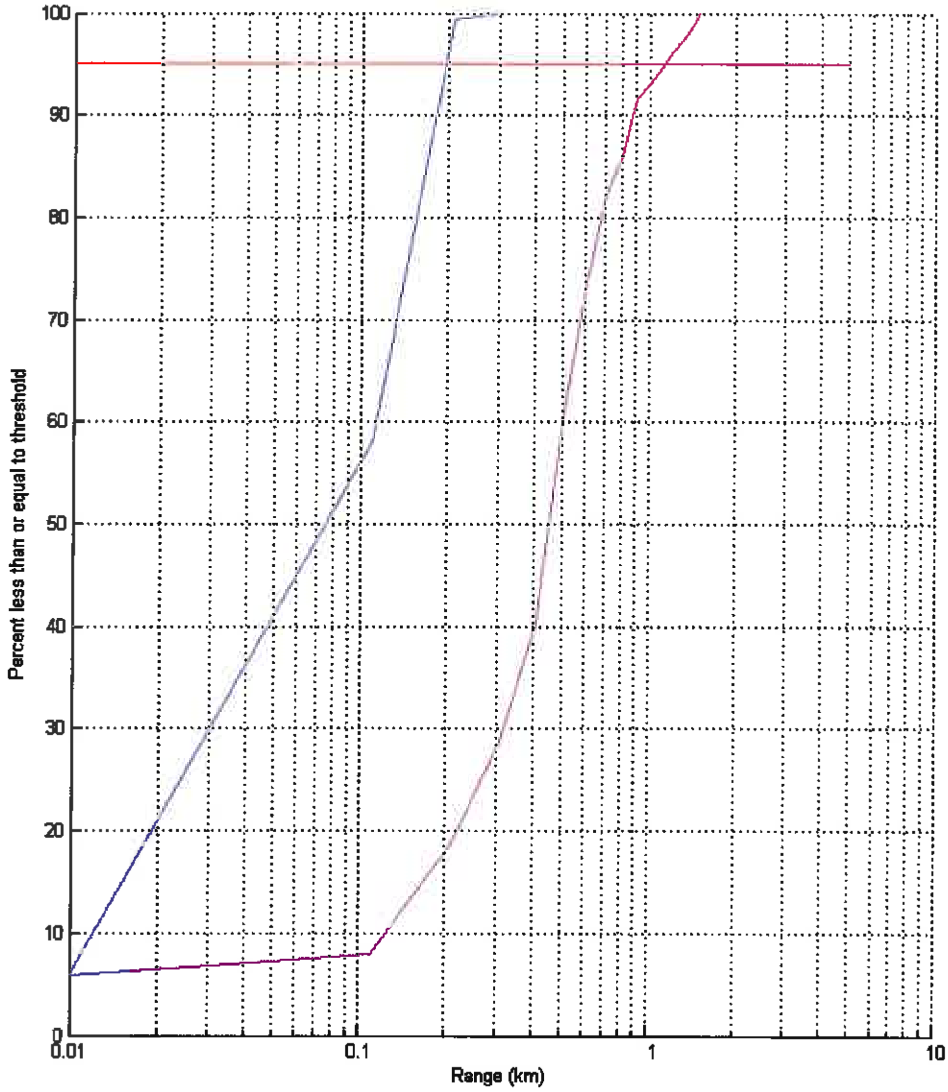


Figure 11. Percentage of received shots below thresholds of 186 dB re 1 μPa^2.s (blue) and 171 dB re 1 μPa^2.s (magenta) as a function of range. Percentages are calculated over all azimuths and depths.

The scatter plot in Figure 12 shows maximum received levels in the water column and all azimuths as a function of range for the S1 source. All of the predicted levels fall below 186 dB re 1 μPa^2.s at a range of 200m at all azimuths and below 171 dB re 1 μPa^2.s for most azimuths at 1km range. Some azimuths near the 90° azimuth (cross-line direction) are predicted to produce levels above or equal to 171 dB re μPa^2.s. Levels along all azimuths are below the 171 dB re 1 μPa^2.s at 1.5 km range.

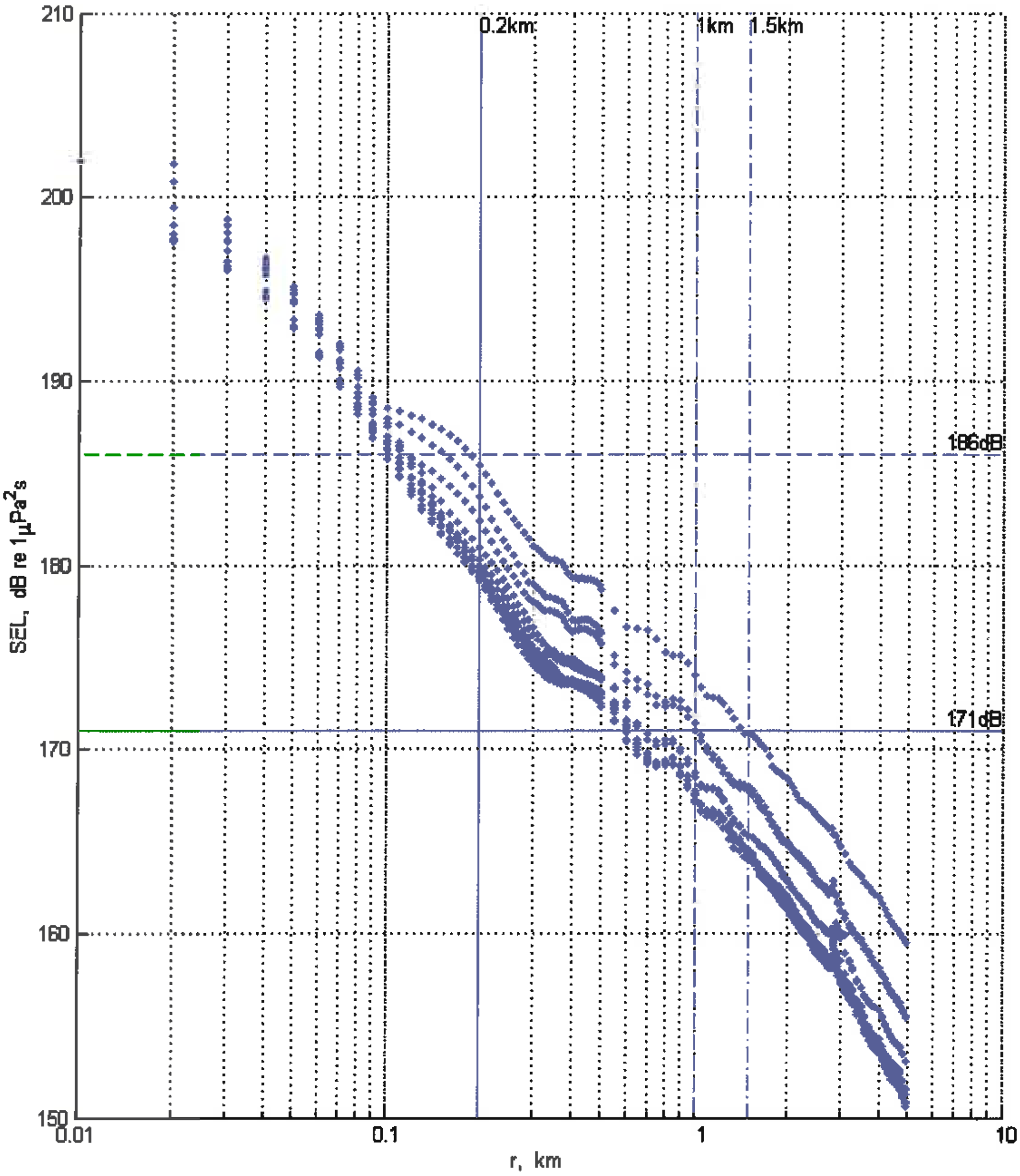


Figure 12. Blue dots are all predicted received levels as a function of range. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 μPa^2.s (solid) and 186 re 1 μPa^2.s (broken).

Various water depths were considered to determine whether sound levels would be below 171 dB re 1 µPa^2.s at 1 km anywhere within the survey area. Given the horizontal plane directionality of the array discussed above and shown in Figure 8 and Figure 9, the maximum SEL levels are expect in the cross-line direction. Figure 13 shows a scatter plot of the predicted SEL in the cross-line direction as a function of range. The different coloured dots are the results for sources in different water depths.

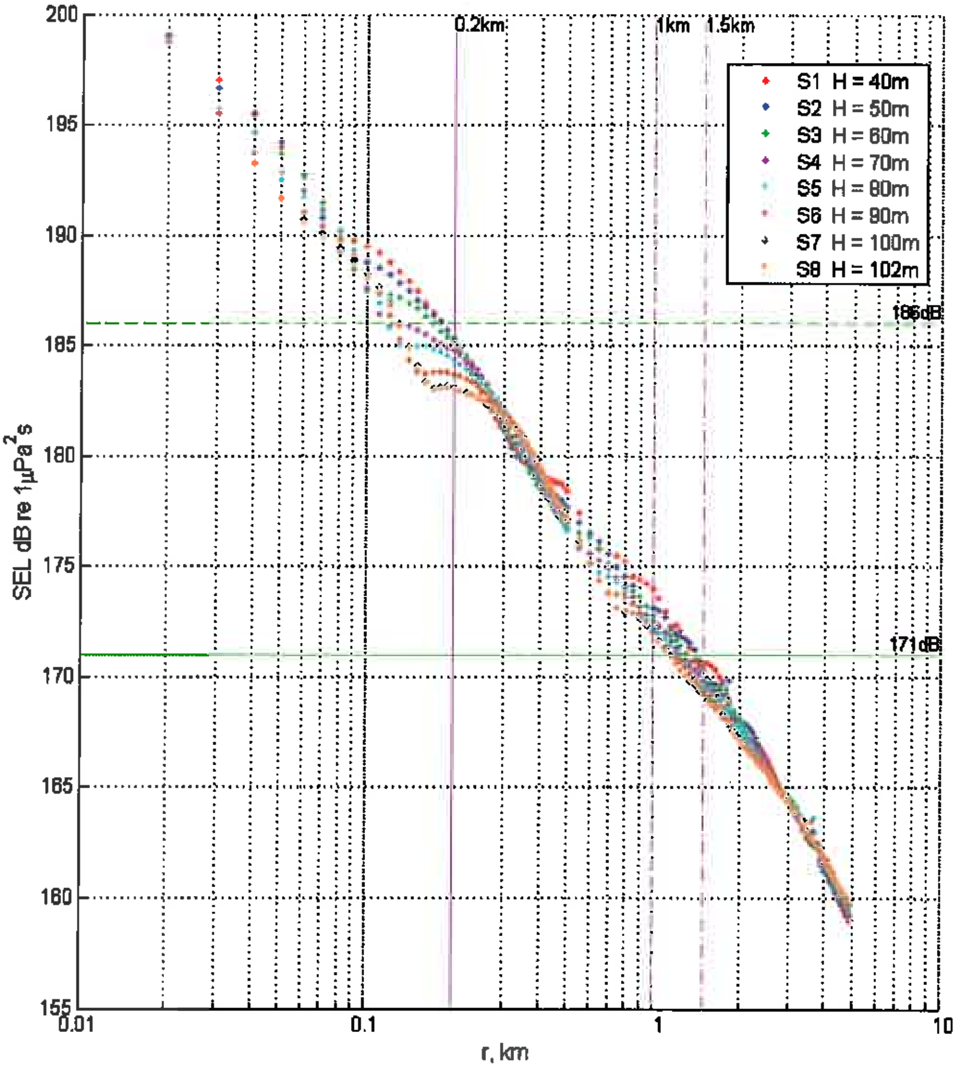


Figure 13. Coloured dots are all predicted received levels in the cross-line direction as a function of range for different water depths. The water depths are represented by the variable "*H*" in the legend. Vertical magenta lines show mitigation ranges of 200m (solid), 1km (broken), and 1.5km (dash-dot). Horizontal green lines show mitigation thresholds of 171 dB re 1 µPa^2.s (solid) and 186 re 1 µPa^2.s (broken).

The levels decrease as the water depth increases, however they do not drop below 171 dB re 1 μPa^2.s at 1 km for any water depth considered. The maximum water depth within the survey area is 102 m; at this depth the received SEL in the cross-line direction is predicted to be 172 dB re 1 μPa^2.s at 1 km and the SEL drops below 171 dB re 1 μPa^2.s at 1.15 km. Since the water depths considered span the maximum and minimum depths within the survey area, it is unlikely that the cross-line SEL will drop below 171 dB re 1 μPa^2.s at 1 km anywhere within the survey area.

4 Conclusions

The modelling method used to produce these results is very computationally intensive but accurately deals with both the horizontal and vertical directionality of the airgun array and with the reflection of acoustic energy from the seabed. Modelling predicted that the Aquila Explorer 2360 cui array operating within the Waru 2D survey in the South Taranaki Bight region will produce received sound exposure levels below 186 dB re 1 μPa^2.s at a range of 200 m. Some receiver azimuths, particularly the cross-line direction, may receive levels above 171 dB re 1 μPa^2.s at a range of 1km. Levels along all azimuths were predicted to be below 171 dB re 1 μPa^2.s at 1.5 km range. At a range of just over 100m, 95% of received sound exposure levels were predicted to be below 186 dB re 1 μPa^2.s, and at a range of about 1.1km, 95% of received sound exposure levels were predicted to be below 171 dB re 1 μPa^2.s. From the sound propagation modelling discussed above the array configuration for the Waru 2D survey is expected to partially meet the sound exposure level requirements of the New Zealand Department of Conservation 2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations.

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