# Pegasus Basin
# 2D Marine Seismic Survey
# Environmental Impact Assessment

## New Zealand Block Petroleum Exploration Permits 54858 and 54861

**Anadarko New Zealand Company**

January, 2014

www.anadarko.com

Anadarko NZ Company

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January, 2014

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## *ABBREVIATIONS*

| Abbreviation | Definition |
|---|---|
| °C | degrees Celsius |
| 2D | 2-Dimensional |
| 3D | 3-Dimensional |
| 4D | 4-Dimensional |
| AEI | Areas of Ecological Importance |
| ALARP | As Low As Reasonable Practicable |
| Anadarko | Anadarko New Zealand Company |
| BOD | Biological Oxygen Demand |
| BPA | Benthic Protection Area |
| cm | centimeters |
| The Code | The 2013 Code of Conduct for Minimizing Acoustic Disturbance to Marine Mammals from Seismic Survey Operations |
| COLREGS | The International Regulations for the Prevention of Collisions at Sea |
| cu in | cubic inches |
| dB | Decibels |
| DOC | Department of Conservation (NZ) |
| EEZ | Exclusive Economic Zone |
| EEZ Act | Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012 (NZ) |
| EIA | Environmental Impact Assessment |
| EHS | Environmental Health and Safety |
| EMP | Environmental Management Plan |
| EPA | Environmental Protection Authority |
| ERM | ERM New Zealand Limited |
| FMA | Fisheries Management Area |
| Hz | Hertz |
| IMO | International Maritime Organization |
| $in^3$ | Cubic inches |
| IOPP | International Oil Pollution Prevention |
| IUCN | International Union for the Conservation of Nature and Natural Resources |
| kg | kilograms |
| km | kilometer |
| $km^2$ | square kilometers |
| km/h | kilometers per hour |
| kHz | Kilohertz |
| l/day | Liters per day |
| m | meters |
| $m^3$ | cubic meters |
| mm | millimeters |
| m/s | meters per second |
| Maritime NZ | Maritime New Zealand |
| MARPOL | International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 |
| MetOcean | MetOcean Solutions Ltd |
| MMIA | Marine Mammal Impact Assessment |

| Abbreviation | Definition |
|---|---|
| MMMP | Marine Mammal Mitigation Plan |
| MMS | Marine Mammal Sanctuaries |
| MfE | Ministry for the Environment (NZ) |
| MFish | Ministry of Fisheries |
| MMO | Marine Mammal Observer |
| MP | Minister of Parliament |
| MPI | Ministry for Primary Industries |
| NABIS | National Aquatic Biodiversity Information System (NZ) |
| NIWA | National Institute of Water and Atmospheric Research Ltd (NZ) |
| nm | nautical miles |
| NZ | New Zealand |
| NZMEC | New Zealand Marine Environment Classification |
| NZPAM | NZ Petroleum and Minerals |
| ORB | Oil Record Book |
| P2P | Pathway to Excellence EHS management system |
| PAM | Passive Acoustic Monitoring |
| PEP | Petroleum Exploration Permit Act 1991 |
| PEPANZ | Petroleum Exploration and Production Association of New Zealand |
| psi | Pounds per square inch |
| RMA Act | Resource Management Act 1991 |
| QMS | Quota Management System |
| Statistics NZ | Statistics New Zealand (national statistical office) |
| SOPEP | Ship Oil Pollution Emergency Plan |
| TAC | Total Allowable Catch |
| The Code | Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (DOC, 2013) |
| UNCLOS | United Nations Convention on the Law of the Sea, 1982 |
| UNEP | United Nations Environment Program |
| UNESCO | United Nations Educational, Scientific, and Cultural Organization |
| µPa | Micropascals |
| µPa@m | Micropascals at one meter |
| WWF | Worldwide Fund for Nature |

# 1 INTRODUCTION

## 1.1 BACKGROUND

This Environmental Impact Assessment (**EIA**) has been prepared for Anadarko New Zealand Company (**Anadarko**) by Environmental Resources Management (**ERM**), a recognized independent international environmental consulting company.

This EIA has been prepared to assess and manage the potential environmental impact of Anadarko's proposed 2-Dimensional (**2D**) marine seismic survey (**MSS**) within the NZ Block Petroleum Exploration Permits (**PEP**) 54858 and 54861 of the Pegasus Basin, to the south of New Zealand (**NZ**)'s North Island and to the east of NZ's South Island (hereafter "the Project Area").

The northwest corner of the Project Area is located approximately 40 kilometers (**km**) south of Wellington and 30 km east of Cape Campbell on the east cost of the South Island, whilst the southeast corner is approximately 150 km southeast from Wellington and 200 km east from Kaikoura. The closest point of the Project Area to land is approximately 25 km south from Cape Palliser on the North Island and the total coverage of Project Area is approximately 23,790 square kilometers (**km²**) (see *Table 1.1* and *Figure 1.1*). The approximate locations of the first 2D MSS lines proposed by Anadarko are shown on *Figure 1.2*. *Figure 1.3* outlines the indicative 'operational area' for the MSS, taking into consideration the area beyond each survey line required for operational activities such as line turns and gun-testing.

*Table 1.1: PEP 54858 and 54861 Details*

| PEP Project Area | Approximate PEP Area (km²) | Water Depth (m) | Distance Offshore (km) |
|---|---|---|---|
| PEP 54858 | 4,273 | 100-2,800 | 25-90 |
| PEP 54861 | 2,812 | | |
| Coordinates for PEP 54858 | | | |
| Point | Latitude | Longitude | |
| 1 | 41° 40' 00" S | 174° 55' 00" E | |
| 2 | 41° 45' 00" S | 174° 55' 00" E | |
| 3 | 41° 45' 00" S | 175° 00' 00" E | |
| 4 | 41° 50' 00" S | 175° 00' 00" E | |
| 5 | 41° 50' 00" S | 175° 35' 00" E | |
| 6 | 42° 10' 00" S | 175° 35' 00" E | |
| 7 | 42° 10' 00" S | 175° 20' 00" E | |
| 8 | 42° 20' 00" S | 175° 20' 00" E | |
| 9 | 42° 20' 00" S | 174° 40' 00" E | |
| 10 | 41° 40' 00" S | 174° 40' 00" E | |

| Coordinates for PEP 54861 | | |
|---|---|---|
| Point | Latitude | Longitude |
| 1 | 41° 30' 00" S | 176° 10' 00" E |
| 2 | 42° 10' 00" S | 176° 10' 00" E |
| 3 | 42° 10' 00" S | 175° 35' 00" E |
| 4 | 41° 45' 00" S | 175° 35' 00" E |
| 5 | 41° 45' 00" S | 175° 45' 00" E |
| 6 | 41° 40' 00" S | 175° 45' 00" E |
| 7 | 41° 40' 00" S | 175° 55' 00" E |
| 8 | 41° 35' 00" S | 175° 55' 00" E |
| 9 | 41° 35' 00" S | 176° 05' 00" E |
| 10 | 41° 30' 00" S | 176° 05' 00" E |
| Datum: NZGD2000 | | |

The purpose of the MSS will be to obtain data that are critical to assessing the potential for hydrocarbons within the Project Area and to identify the optimum potential locations for future exploration wells. The first survey is scheduled to commence in the last week of January 2014.

Depending upon the survey results, follow-up 2D or 3-Dimensional (**3D**) marine seismic survey and exploration drilling activities might be necessary to further detail the hydrocarbon potential of the basin. The environmental impacts of potential future exploration drilling activities within the Project Area that may result from the MSS data are not within the scope of this EIA and will be discussed in subsequent EIAs.

The overall purpose of this EIA is to:

- Present the current understanding of the key environmental sensitivities related to the proposed MSS program;
- Assess the potential environmental impacts to the surrounding environment as a result of project activities;
- Present measures that will be implemented to avoid or minimize adverse impacts to the surrounding environment; and
- Fulfil the requirements for a Marine Mammal Impact Assessment (**MMIA**) under the NZ Department of Conservation (**DOC**)'s *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations* (the '**Code**') (DOC, 2013b).

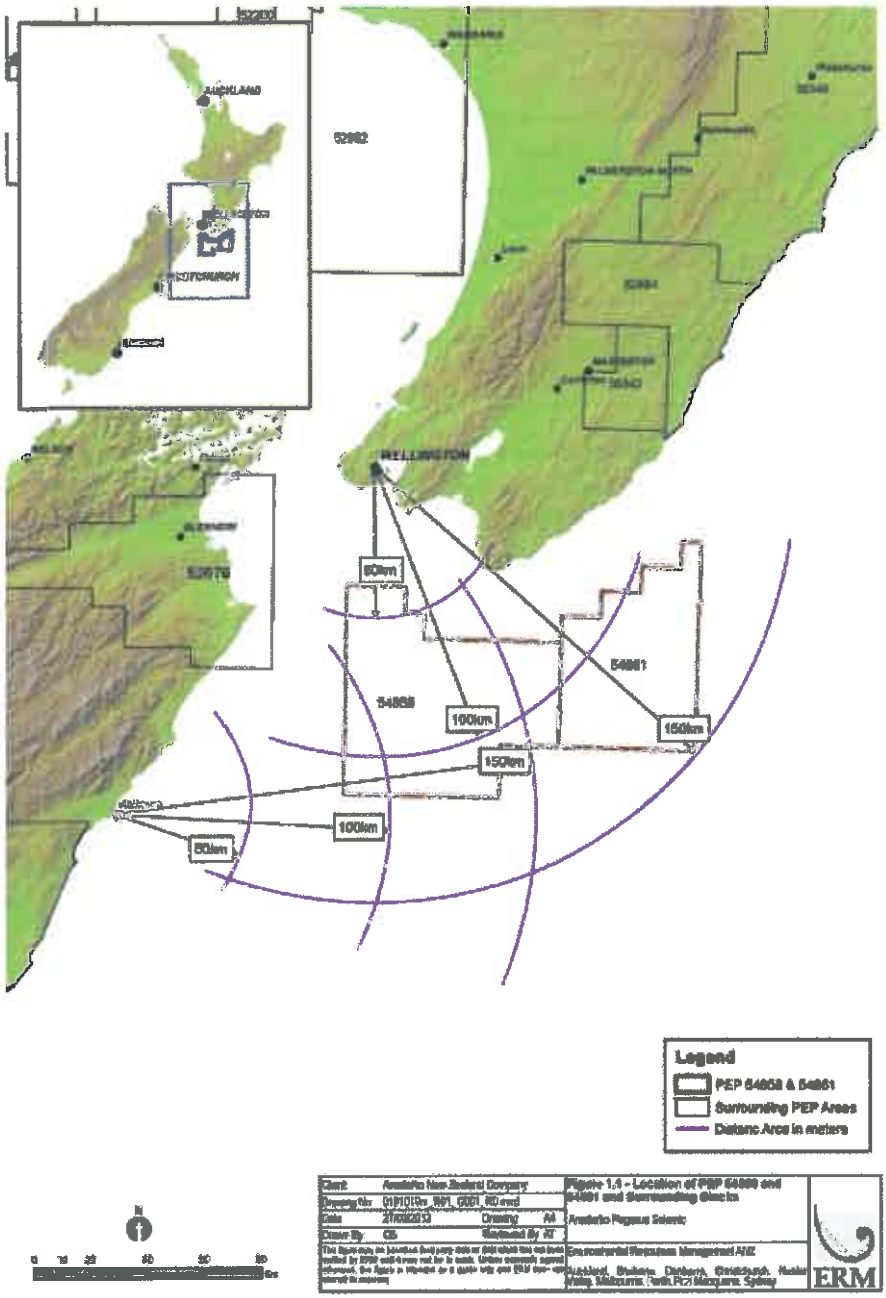



*Figure 1.1: Location of PEP 54858 and 54861 and Surrounding Blocks*

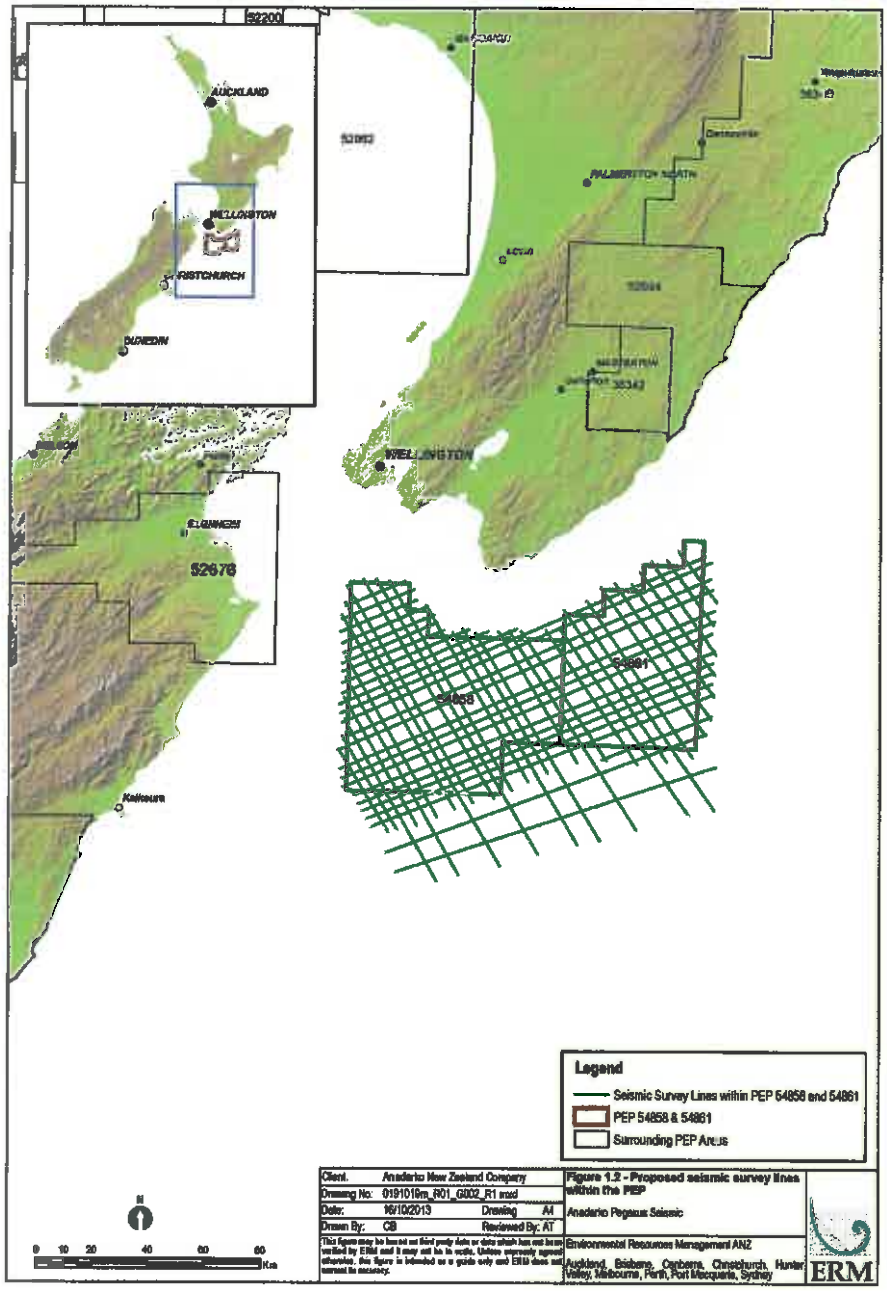
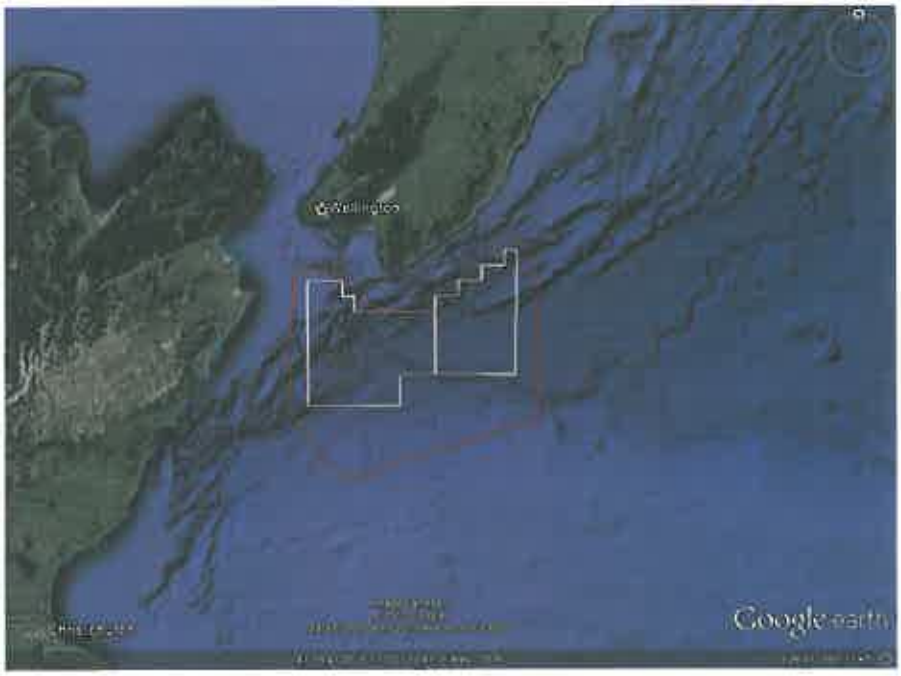



*Figure 1.2: Proposed MSS Lines within PEP 54858 and 54861*




*Source: Google Earth, NZ PAM (https://data.nzpam.govt.nz/permitwebmaps/default.aspx?commodity=petroleum) and Anadarko (Pers. Comm.)*

*Figure 1.3: Indicative Operational Area for MSS*

## 1.2 OBJECTIVES AND GENERAL APPROACH

This EIA report covers Anadarko's planned seismic survey operations to support oil and gas exploration within the Project Area (hereafter "the Project").

This EIA is part of the overall planning effort for Anadarko's exploration program, which is being conducted in accordance with the applicable NZ laws and regulations at the time of issue, international guidelines and procedures, and with Anadarko's Environment, Health and Safety (**EHS**) Policy.

The primary national legislation managing offshore activities in NZ's Exclusive Economic Zone (**EEZ**), including oil and gas exploration, is the *Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* (the EEZ Act). The *Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013* (the Regulations) were promulgated and came into force on 28 June 2013. Under Section (s.) 7 of these regulations, seismic surveys are prescribed as permitted activities, subject to compliance with the Code. Further detail on policy, legal and administrative framework is provided in *Section 2*.

### 1.2.1 *Marine Mammal Impact Assessment*

The Code requires pre-survey planning, including notification and the submission of an MMIA to DOC. A key objective of this EIA is to fulfil the MMIA requirements detailed in Appendix 1 of the Code. The purpose and specific content requirements of an MMIA are set out in Appendix 1 of the Code. *Table 1.2* documents where these requirements are addressed within this EIA.

*Table 1.2: MMIA Requirements Cross Reference*

| DOC Code of Conduct MMIA Requirement | Relevant EIA Section |
|---|---|
| Describe the activities related to the proposed marine seismic survey | *Section 3* |
| Describe the state of the local environment in relation to marine species and habitats, with particular focus on marine mammals, prior to the activities being undertaken | *Section 4* |
| Identify the actual and potential effects of the activities on the environment and existing interests, including any conflicts with existing interests | *Section 6* |
| Identify the significance (in terms of risk and consequence) of any potential negative impacts and define the criteria used in making each determination | *Section 5* |
| Identify persons, organizations or tangata whenua with specific interests or expertise relevant to the potential impacts on the environment | *Section 1.5 and 4.5.2* |
| Describe any consultation undertaken with persons described above and specify those who have provided written submissions on the proposed activities | *Section 1.5 and 4.5.2* |
| Include copies of any written submissions from the consultation process | *Annex A* |
| Specify any possible alternative methods for undertaking the activities to avoid, remedy, or mitigate any adverse effects | *Section 1.7* |
| Specify the measures that the operator intends to take to avoid, remedy, or mitigate the potential adverse effects identified | *Section 6 and Section 7* |
| Specify a monitoring and reporting plan | *Section 8 and Section 9* |
| Specify means of coordinating research opportunities, plans, and activities relating to reducing and evaluating environment effects. | *Section 9* |

## 1.3 *Location and Timing*

The spatial extent of the MSS is displayed on *Figure 1.2* and the coordinates are presented in *Table 1.1*. Anadarko plans to initiate the first planned seismic survey within the Project Area in the last week of January 2014. Water depths for this first survey range from 100 m to around 2,800 m.

Some data have previously been collected within the Project Area, so the purpose of this MSS is to fill in data gaps to provide complete coverage to assess the potential for hydrocarbon recovery within PEP 54858 and/or PEP 54861.

The MSS will be executed on behalf of Anadarko by specialist contractors GardlineCGG, using the vessel *MV Duke* across an approximately 42 day period, 24 hours per day, 7 days a week, subject to suitable weather conditions, and marine mammal encounter protocols (*Section 9*). Should the weather be severe enough to require the vessel to leave the Project Area, all reasonable attempts will be made to shelter at the NZ mainland.

## 1.4 CONSULTED SOURCES OF INFORMATION

The description of the existing environment presented in *Section 4* is based on a review of existing data/literature from international and local sources of information. Anadarko accessed the following sources as inputs to the environmental baseline:

- Oceanographic and climatological information was obtained from previous reports on the Pegasus Basin and data by the NZ National Institute of Water and Atmospheric Research Ltd (**NIWA**);
- The general ecological and fisheries baseline was derived from selected species accounts, plenary documents, and other online information compiled by the NZ Ministry of Primary Industries (**MPI**, formerly Ministry of Fisheries (**MFish**));
- Information on threatened species was obtained primarily from the DOC's *Threat Classification Lists* (DOC 2005, 2011) and the MPI *National Aquatic Biodiversity Information System* (**NABIS**) species distribution maps (MPI, 2013m);
- Information on marine mammals, seabirds, and plankton was primarily obtained from MPI, the Worldwide Fund for Nature (**WWF**), the International Union for Conservation of Nature (**IUCN**) and the American Cetacean Society;
- Information on protected natural areas (including marine reserves, benthic protection areas and marine mammal sanctuaries) was obtained from a series of informational reports issued by United Nations Environment Program (**UNEP**), DOC and MPI;
- Population, ethnicity, and income data were derived from the Statistics New Zealand (**Statistics NZ**) online database;
- Information on ports and harbors was obtained from shipping trade sources and NZ Petroleum and Minerals (formerly NZ Crown Minerals); and
- Economic data on fisheries were acquired from Statistics NZ and MPI. Details of stakeholder consultation that further informed this assessment are included in *Section 1.5*.

Local specialists were involved in selecting, acquiring, and synthesizing relevant documentation.

## 1.5 CONSULTATION

The Code requires operators to:

- Identify persons, organizations or tangata whenua with specific interests or expertise relevant to the potential impacts on the environment;
- Describe any consultation undertaken with persons described above and specify those who have provided written submissions on the proposed activities;
- Identify the actual and potential effects of the activities on the existing interests, including any conflicts with existing interests; and
- Include copies of any written submissions from the consultation process.

Anadarko has initiated a program of stakeholder engagement in order to inform the following groups and individuals of its intended activities. The full list of parties that Anadarko has consulted with is provided in *Annex A*.

Those parties consulted with existing interests include:

- Iwi and hapu groups: Māori tribal groups that are generally associated with a recognized territory (or rohe);
- Local business interests;
- Local fishing interests; and
- Local non-governmental organizations and environmental groups that have an expressed interest in the project.

In addition the following parties were consulted:

- Local government (district and regional councils);
- Local Ministers of Parliament (**MPs**);
- Ministry for the Environment (**MfE**);
- Environmental Protection Authority (**EPA**);
- Maritime New Zealand (**Maritime NZ**);
- DOC;
- The NZ Minister of Energy & Natural Resources;
- NZ Petroleum and Minerals (**NZPAM**);

- The NZ Ministry of Business, Innovation and Employment, including the former NZ Ministry of Economic Development and NZ Department of Labour;
- Maori electorate MPs:
  - Rino Tirakatene, MP for Te Tai Tonga; and
  - Meka Whaitiri, MP for Ikaroa-Raawhiti;
- Environmental Groups:
  - Forest and Bird; and
  - WWF New Zealand.

Details relating to the consultation and concerns raised during the consultation process can be found in *Section 4.5.2* of this EIA.

## 1.6 LIMITATIONS

The work described herein was conducted following accepted procedures consistent with the current standard of practice in NZ, as well as the objectives and scope of work agreed upon with Anadarko. In accordance with the agreed scope of work, this EIA was prepared on the basis of published information in existence at the time of report issuance (January 2014) that could be readily obtained from relevant online and local sources. The conclusions and recommendations presented herein are based on these data and NZ expert technical review of these and other data and are limited as such. Baseline field studies were not completed as part of this work.

## 1.7 PROJECT RATIONALE AND ALTERNATIVES

### 1.7.1 *Project Rationale*

Developing energy resources remains a cornerstone of the Government's plan for economic growth. It places a high value on the oil and gas estate and, through its Energy Strategy 2011–2021, is committed to developing its potential (MED, 2010). The immediate focus is on increasing exploration activity and on improving the knowledge of NZ's petroleum basins.

Geological information for the area has been investigated and it was concluded that seismic work is required to determine the hydrocarbons potential for the Pegasus Basin.

### 1.7.2 *Alternative Locations*

The potential resource which the Project is investigating is located within PEP 54858 and PEP 54861. The location of the resource as well as the extent of the PEP's are definitive thus alternative locations are not possible.

### 1.7.3 *Alternative Methods*

Alternative methods that are being considered are largely technology related, such as the type of seismic vessel and associated seismic equipment such as the size of the acoustic source. Alongside suitability for the Project objectives, all alternatives are being considered based on environmental and safety risk primarily, with cost being a secondary but necessary consideration. These are discussed below.

#### *Seismic Vessel*

A range of potential seismic vessels were investigated for suitability for this survey. The vessel, the *MV Duke*, was selected due to her ability to achieve the data acquisition objectives for the survey, while doing so in a safe and reliable manner. The use of smaller vessels would increase the duration of the survey, and therefore the period of disturbance to marine fauna, as well as presenting increased safety risks. More information on the vessel can be found in *Section 3.4*.

#### *Acoustic Source*

Selecting the acoustic source required consideration of the potential disturbance to the environment while still ensuring the survey achieves the data acquisition objectives based on the water depth and Anadarko's understanding of the geological formations and target strata depths for the survey. In this instance, it is proposed to have the option of up to 3610 in3 to ensure the optimal balance is achieved as use of a smaller seismic source may result in the need to resurvey the area. More information on the acoustic source can be found in *Section 3.4*.

*Type of Survey*

The selection of the MSS type for the current survey is based on the data acquisition requirements for the Project. Seismic surveys are typically either 2D or 3D. 2D and 3D surveys are used primarily for prospecting, exploration and characterization of undeveloped resources. Typically, 2D surveys are conducted over wide areas with survey lines spaced at 2 km-10 km intervals and with data collected by hydrophones in a single towed streamer. These surveys provide a broad overview of submarine geology. 3D surveys are conducted across smaller spatial extents with survey lines paced at 300 - 500 m apart and with data collected by multiple seismic streamers. These surveys provide sufficient data to construct a 3D model of the submarine strata. This project will involve the collection of 2D data due to the need for a general geological overview across a larger spatial extent. More information on the survey can be found in *Section 3.4*.

### 1.7.4 *Do Nothing Option*

As part of the work program for each of the PEPs, Anadarko are required to commit to exploration activities, thereby furthering investigations into the resource potential of the PEPs as well as the wider Pegasus Basin. If Anadarko were to not to undertake the seismic survey they would need either to surrender the PEPs back to the Crown or to undertake exploration drilling activities without adequate data to select the drilling target, potentially resulting in environmental disturbance for an extended duration with little chance of project success. The 'do nothing' option is therefore not considered to be a viable alternative.

# 2 POLICY, LEGAL, AND ADMINISTRATIVE FRAMEWORK

## 2.1 NATIONAL LEGISLATION

National legislation applicable to the offshore oil and gas sector and relevant legislation in terms of environmental protection, maritime activities, biosecurity and industrial safety, and cultural and archaeological heritage, includes:

- *Exclusive Economic Zone and Continental Shelf (Environment Effects) Act 2012* (the **EEZ Act**);
- *Exclusive Economic Zone and Continental Shelf (Environment Effects-Permitted Activities) Regulations 2013* (the **EEZ Permitted Activity Regulations**);
- *Resource Management Act 1991* (the **RMA**) and associated *Resource Management (Marine Pollution) Regulations 1998*;
- *Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 2013*;
- *Maritime Transport Act 1994*, and the associated Marine Protection Rules and Advisory Circulars under the *Maritime Transport Act 1994*, plus Maritime Rules relating to associated supporting maritime activities (currently under review);
- *Biosecurity Act 1993*, as amended, including the NZ Import Health Standard for Ballast Water from all Countries;
- *Marine Mammals Protection Act 1978*, and the associated *Marine Mammals Protection Regulations 1992* ;
- *Continental Shelf Act 1964*;
- *Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977*;
- *Wildlife Act 1953*; and
- DOC 2013 *Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Activities* (**the Code**)[1].

[1] Note, whilst the Code is not a legislative document, the Regulations prescribe that MSS activities are permitted activities subject to conformance with the Code.

### 2.1.1 *The EEZ Act*

The *EEZ Act* was developed and enacted in 2012 in order to address the jurisdictional inconsistencies and to fill an overarching gap in the regulation of activities within NZ's EEZ and Continental Shelf. The *EEZ Act* seeks to manage the environmental effects of activities in NZ's oceans and to protect them from the potential environmental risks of activities such as petroleum exploration, seabed mining, marine energy generation and carbon capture developments.

The EEZ Act came into force on 28 June 2013 when the EEZ Permitted Activity Regulations were promulgated. These regulations specify the activities that are to be permitted activities for the purposes of Section (s.)20 of the EEZ Act and the conditions for undertaking these permitted activities. Under s.7 of the Regulations, seismic surveys are prescribed as permitted activities, subject to compliance with the Code.

### 2.1.2 *The Code*

The Code was developed by DOC and, in its current form, came into effect in December 2013. The objective of the Code is to minimize acoustic disturbance to marine mammals from seismic operations. The guidelines outlined aim to minimize potential impacts without unduly affecting normal operations. These guidelines have been endorsed by the Petroleum Exploration and Production Association of New Zealand.

This Project will be considered a Level 1 survey with a total combined operational capacity of the acoustic source exceeding 427 cubic inches. Of each of the survey classifications within the Code, Level 1 surveys are subject to the most stringent requirements for marine mammal protection (DOC, 2013b). The key requirements of a Level 1 survey are:

- Pre-survey planning including notification of DOC and the submission of an MMIA;
- Requirements for two qualified Marine Mammal Observers (**MMOs**) and two qualified Passive Acoustic Monitoring (**PAM**) operators on board the survey vessel; and
- Specific operational requirements around pre-start observations, delayed starts and shutdowns.

Where seismic activities are planned to be undertaken in regions defined by DOC as Areas of Ecological Importance (AEI), the Code requires a sound transmission loss modelling component to be incorporated into the MMIA methodology. This modelling is required to indicate predicted sound levels within the various mitigation zones and potential impacts on species present. As the Project Area falls within an AEI, sound transmission loss modelling has been undertaken and results discussed in this EIA (refer to full modelling report in *Annex B* and results summary in *Section 6*).

*Areas of Ecological Importance (AEI)*

AEI are marine areas under the protection of the NZ government for their importance to marine mammals and other important marine species.

The project area is located within an AEI (**see** *Section 4.2.10*). According to DOC, under normal circumstances marine seismic surveys are not to be planned in any sensitive, ecologically important areas or during key biological periods where Species of Concern are likely to be breeding, calving, resting, feeding or migrating, or where risks are particularly evident such as in confined waters (for example, embayments or channels). However, where conducting surveys in such areas and seasons is demonstrated to the satisfaction of the Director-General to be necessary and unavoidable, further measures may be required to minimize potential impacts. In these instances, proponents are required to seek advice from the Director-General to develop and agree on mitigation strategies for implementation. This should lead to the development of an appropriate marine mammal mitigation plan for use by observers and crew to guide operations. Further, the Code specifies that a core component of the planning process is for the exploration permit holder to determine the lowest practicable power levels for the acoustic source array that will achieve the geophysical objectives of the survey—and to limit operations to this maximum level.

In this instance, Anadarko has identified the optimal balance of achieving the data acquisition objectives of the survey while minimizing the disturbance to the marine environment (see *Section 1.7.3*). Anadarko is able to proceed, providing sound transmission loss modelling is incorporated into this MMIA; specifically the Code requires for sound levels of 171 dB re 1 µPa2-s at and 186 dB re 1 µPa2-s at 200 m to be modelled (DOC, 2013b). As per these requirements, sound loss transmission modelling was conducted as part of this EIA and is discussed in *Section 6*.

The outputs of the model will be ground-truthed during the MSS, using a combination of sail past and moored monitoring methods, described in more detail below.

The sail past method follows the international standard ISO specification 17208-1 for *Acoustics - Quantities and procedures for description and measurement of underwater sound from ships* (ISO, 2012). This method consists of deploying hydrophones from a support vessel and measuring the sound transmission to the beam of the source.

A second methodology is proposed by Anadarko to measure the sound transmission in a vertical direction. The moored monitoring method involves the placement of two acoustic recording units (**ARUs**) on the seabed using dissolvable moorings. These are recovered with acoustic releases. In line with ISO standards, wind speed must be ≤ 20 knots for these measurements to take place.

### 2.1.3 *Other Regulatory Updates*

Other relevant legislative developments underway at the time of issue of this EIA include proposed amendments to the *Maritime Transport Act 1994* contained within the *Marine Legislation Bill 2012*.

Amongst other things, the *Marine Legislation Bill 2012* seeks to transfer responsibility for regulating certain discharges and dumping of waste under Parts 180 of the Marine Protection Rules from Maritime NZ to the EPA.

## 2.2 *International Conventions, Treaties, Agreements, and Programs*

The following international agreements and conventions may affect petroleum activities in marine waters off NZ.

### 2.2.1 *International Regulations for the Prevention of Collisions at Sea, 1972*

The International Regulations for the Prevention of Collisions at Sea (**COLREGS**) specifies the conduct of vessels on the high seas, and provides a standard set of operational expectations and navigation procedures for maritime vessels. NZ ratified the convention in 1972. COLREGS is implemented in NZ under the *Maritime Transport Act 1994* regime in NZ.

### 2.2.2 *International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978*

The International Convention for the Prevention of Pollution from Ships 1973 as modified by the Protocol of 1978 (**MARPOL**) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively, and updated by amendments through the years. NZ is signatory to Annex I – Oil, Annex II – Noxious Liquid Substances Carried in Bulk, Annex III – Harmful Substances Carried in Packaged Form and Annex V – Garbage. These annexes are enacted through the *Maritime Transport Act 1994* and supporting instruments.

### 2.2.3 *United Nations Convention on the Law of the Sea (UNCLOS), 1982*

UNCLOS was completed in Montego Bay, Jamaica, on the 10th of December 1982. The objective is to set up a comprehensive new legal regime for the sea and oceans; including rules concerning environmental standards as well as enforcement provisions dealing with pollution of the marine environment. NZ ratified the convention in 1996, and it is in force in NZ via a number of statutes including the *Crown Minerals Act 1991* (through which petroleum exploration permits are awarded) and the *Maritime Transport Act 1994* and related Rules.

### 2.2.4 *Convention on Biological Diversity, 1992*

The objective of the Convention on Biological Diversity is the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The Convention is the first international agreement to view biological diversity as a resource over which nation states have sovereign rights. Biological diversity in signatory nations has thus attained the same status as mineral and other natural resources. NZ ratified the convention in 1993.

### 2.2.5 *Convention Concerning the Protection of the World Cultural and Natural Heritage (Paris, 1972)*

The Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) was adopted by the United Nations Educational, Scientific, and Cultural Organization (**UNESCO**) General Conference on the 16th of November 1972. The World Heritage Convention aims to promote cooperation among nations to protect heritage around the world that is of such outstanding universal value that its conservation is important for current and future generations. NZ ratified the convention in 1984.

### 2.2.6 *Anadarko's Internal Environmental Policies and Standards*

The management of environmental risks associated with Anadarko's activities is integral to Anadarko's business decision-making processes. Environmental hazards are identified during planning and throughout operations, and their associated risks are assessed and managed via a structured Pathway to Excellence EHS management system (**P2E**). This is the mechanism that ensures that Anadarko's standards are maintained, the commitments specified in this EIA are met, and that unforeseen aspects of the proposed MSS program are detected and addressed.

An Environmental Management Plan (**EMP**) is integral to implementation of Anadarko's P2E program for the proposed project activities. This plan will detail regulatory requirements and commitments outlined in this EIA, along with monitoring and reporting requirements (refer to *Section 8* for further details).

A Marine Mammal Mitigation Plan (**MMMP**) has also been developed to fulfil the requirements of the Code. This includes protocols that will be followed by the MSS vessel to minimize impacts on marine mammals (refer to *Section 9* for further details).

# 3 PROJECT DESCRIPTION

## 3.1 OVERVIEW

Anadarko proposes to undertake a 2D MSS within PEPs 54858 and 54861 of the Pegasus Basin (refer to *Figure 1.1* and *Figure 1.2*). The Project is planned to commence in the last week of January 2014, with duration of approximately 42 days.

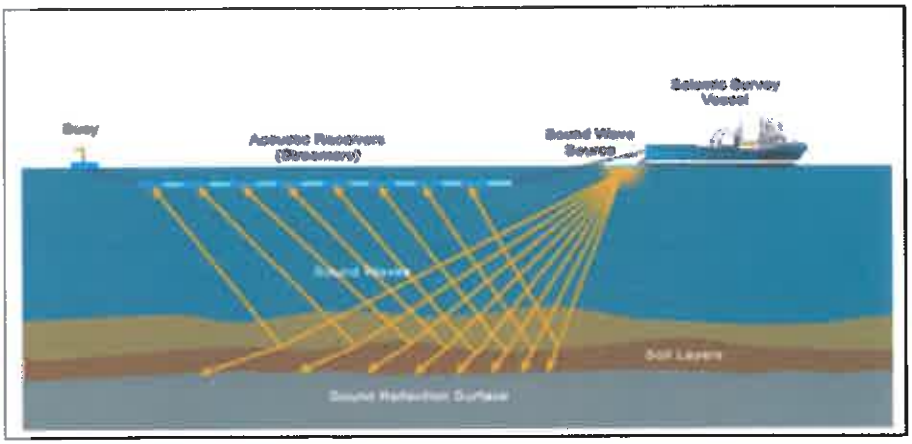
A number of MSS studies have previously been undertaken in the Project Area prior to the current exploration phase, including an approximate 2,800 km 2D industry-standard survey acquired across much of the basin by Crown Minerals in 2010 (NZ Petroleum and Minerals, 2012). A multi-beam survey was undertaken in the Project Area by Anadarko in April 2013. Further MSS activities may be undertaken in subsequent phases of the exploration program to further support Anadarko's exploration and appraisal objectives. Details of the currently planned MSS are described below.

## 3.2 MARINE SEISMIC SURVEY (MSS) METHOD

MSS are routinely conducted in offshore exploration and production operations worldwide to define subsurface geological structures. These surveys are currently the best feasible technology to accurately prospect for offshore hydrocarbons.

MSS are carried out by purpose-built survey vessels that collect subsurface geological data along a set grid of transect lines and can be 2D, 3D, or 4-Dimensional (4D). The proposed MSS program incorporates a 2D survey. This type of survey is used primarily for exploration and characterization of undeveloped resources. Typically, the seismic vessel will tow a single hydrophone streamer below the water, which can measure up to 10,000 m in length. When surveying equipment is in the water, vessel speed will likely be no less than 3.5 knots (6.5 km/h) and no more than 5.5 knots (10 km/h). The initial deployment of the streamer can take up to 24 hours with the potential for extra time being required for troubleshooting.

MSS use sound energy sources to create seismic waves in the Earth's crust beneath the sea. Low frequency sounds, usually in the form of short-duration pulses, are created along the transect grids. The pulses travel through the geological strata and are reflected from the boundaries of geological strata in the subsurface. The reflected pulses are subsequently recorded by receivers (hydrophones) near the water surface (*Figure 3.1*). The depths of the reflecting geological strata are calculated from the time elapsed between the sound generation and detection of the reflected signal by the hydrophone. Analysis of the return time and character of signals allows the definition of the underlying geological structures.




*Source: UK Fisheries Offshore Oil & Gas Legacy Trust Fund Limited (FTLC, no date)*

*Figure 3.1: Schematic of MSS Method*

In its most basic form, MSS equipment consists of an acoustic source, an acoustic receiver, and a data storage device. Airguns are commonly used as an energy source. A seismic airgun is an impulsive underwater transducer that produces sound energy at low frequencies. Airguns function by venting high-pressure air into the water. This produces an air-filled cavity that expands rapidly, then contracts, and re-expands. A seismic wave is created with each oscillation. During operation, air at high pressure (nominally 2000 pounds per square inch) is supplied continuously to the airgun.

Airgun arrays are designed to direct a high proportion of the energy vertically downwards. However, energy is also projected horizontally into the water, and can be detected at different distances from the source (depending on hydrographical conditions and level of background noise).

With increasing distance from the source, pulses received from an airgun array decrease in amplitude. The pulses from the guns are broad band, with most energy concentrated in the 10-200 Hz frequency range, with lower levels in the 200-1000 Hz range. Depending upon how many guns are fired together, sound levels at the source range from 237-262 dB re 1µPa@m.

The seismic signals reflected by boundaries in the subsurface geology are received by hydrophones (pressure sensors) carried in the streamer cable towed behind the seismic vessel. The cable sections are buoyant and connected together with electronic modules in which the signals from the hydrophones are digitized and put onto an optical carrier, which returns the signals to the recording system on board the vessel.

## 3.3 TYPICAL SURVEY ELEMENTS

MSS are undertaken by specialist contractors on a project-by-project basis, with contractor availability affecting selection of the exact vessel used for each activity. Survey vessels are self-sustaining and come equipped with a trained crew of officers, scientists and support staff along with specialized survey equipment. The seismic vessel that will be contracted for the Project is the *MV Duke*. At least two support vessels will also be contracted by Anadarko. Further detail on these vessels is provided in the sections below. Project details are subject to change if operational revisions occur.

## 3.4 MSS VESSELS

All seismic and support vessels used in the Project will comply with the *Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993)*, *Maritime Transport Act 1994*, MARPOL and the relevant NZ Marine Protection Rules in having current International Oil Pollution Prevention Certificates and International Sewage Pollution Prevention Certificates, applicable certifications and current inspections for the vessel class, pollution control equipment and systems, discharges at sea, crewing standards and requisite liability insurances.

### 3.4.1 *Seismic Vessel*

The GardlineCGG owned vessel, the *MV Duke*, is a well-established, multi-role exploration survey vessel (*Figure 3.2*). The vessel is 66.8 m long and has a fuel capacity of 660 $m^3$. The vessel has a cruising speed of 10 knots and has the capacity to carry enough fuel, water, and supplies to operate for 50-60 days without the need for support. Bunkering will take place in the port of Wellington upon arrival in country. The vessel is equipped with a full hospital. It is anticipated that a crew of approximately 38 personnel will be required for the survey (15 marine vessel crew, 21 survey crew and two company representatives). *MV Duke* will return to the port of Wellington to allow for one crew change after 28 days, in accordance with NZ requirements. The vessel will be bunkered and resupplied at this time. No bunkering operations will occur at sea.

A single source array of multiple airguns will be utilized on the *MV Duke*. The array will comprise 22 active guns and 10 spare guns which fire simultaneously, producing a cumulative source volume of 3,610 cu in. Individual airgun volumes range from 40 cu in to 300 cu in. Operating pressure will be 2,000 pounds per square inch (**psi**). The streamer system adopted for the 2D MSS will be one solid foam streamer, 8,100 m in length. The streamer will be towed at a depth of 18 m, the air guns at 12 m, unless sea states and geological conditions warrant changes in towing depth.

*Source: GardlineCGG*

*Figure 3.2: MV Duke*

### 3.4.2 Support Vessels

Two support vessels will be used in conjunction with the main survey vessel. An example of a support vessel is illustrated in *Figure 3.3*. The role of the support vessel is to notify other vessels operating in the area to steer clear of the seismic vessel, streamers and tail buoys and to provide additional support as needed. Typically support vessels are around 35-50 m in length.

*Source: Seaworks Ltd (www.seaworks.co.nz)*

*Figure 3.3: An Example of a Seismic Support Vessel*

### 3.4.3 *Typical MSS Program*

The main elements of a MSS are:

- *Mobilization of the vessels to the Project Area*: the vessels will be fully provisioned before mobilization. Any vessels arriving into the Project Area from overseas ports will comply with the *Biosecurity Act 1993*, including the *Import Health Standard for Ships' Ballast Water from All Countries and the Import Health Standard for Vessel Biofouling*. Crew changes and supply replenishment will be carried out as needed. The survey vessel will be accompanied by the support vessels for the duration of the MSS;

- *Deployment of the towed equipment*: typically, the survey vessel uses prevailing wind and currents to facilitate the deployment of the towed equipment; and

- *Data acquisition and evaluation*: during data acquisition, the survey vessel will follow predetermined survey lines that may be subject to change depending on prevailing current and wind conditions. Following data acquisition, the survey vessels leave the survey area, the data are processed, and the processed data are analyzed by Anadarko to evaluate whether further exploration is required.

A summary of the seismic survey equipment specifications are provided below in *Table 3.1*.

*Table 3.1: Summary Table of Seismic Survey and Equipment Specifications*

| | |
|---|---|
| Duration of Seismic Activity | Approximately 42 days (accounting for potential project delays) |
| Survey Area | Approximately 7085 km² |
| Seismic Source Size | 3610 in³ from a single source array |
| Source Number | 22 active guns |
| Source Width | 24m |
| Source Length | 12m |
| Subarray separation | 8m |
| Number of subarrays | 4m |
| Firing Timing | Energy source will sound at 25m intervals, resulting in a cycle time of approximately 12 seconds at an operating speed of 8 km/hr |
| Time to complete each transect | 2.5 hours per line change |
| Distance between transects | 3–5 km spacing |

| | |
|---|---|
| Number of Streamers | One solid foam streamer |
| Length of Streamers | 8,100 m |
| Towing Depths of the Source and Streamers | 12 m (source), 18 m (streamer) |
| Towing Speed | 3.5 – 5.5 Knots |
| Data acquisition length | ~4,300 line-kilometers. |

## 3.5 SAFETY PRECAUTIONS

### 3.5.1 *Navigation Safety*

During the MSS activities, it is important that other vessels are aware of the planned movements, including turns and short-distance repeat paths, of the survey vessel. As well, other vessels must not pass too close to the stern of seismic vessels to avoid entanglement or damage to equipment or vessels. Commercial and other vessels will be notified of the MSS activities by appropriate signals in accordance with International Maritime Law. A Coastal Navigation Warning will also be posted by Maritime NZ at the request of Anadarko for the duration of the survey. Communications will be conducted via radio, AIS, lights, and flags. Two support vessels will be used during all survey activities and will be used to liaise with small fishing boats or other marine users in the area that are potentially unaware of the MSS program. Navigation will be conducted in accordance with the International Regulations for Preventing Collisions at Sea *1972* COLREGS.

# 4 THE EXISTING ENVIRONMENT

## 4.1 PHYSICAL ENVIRONMENT

### 4.1.1 Climate

Detailed climatological data, such as mean temperature and precipitation, are unavailable for the Project Area, so the following description is based on data from the onshore south coast of the North Island, in the Greater Wellington region of NZ. This area was selected to represent the Project Area due to the availability of data and its proximity to the Project Area.

NZ lies in the path of the Roaring Forties, the prevailing westerly winds found in the Southern Hemisphere between the latitudes of 40 and 50 degrees. The central North Island mountain ranges deflect these winds through Cook Strait, the narrow gap between the North and South Islands, and funneled through this passage, they become faster and stronger. Gusty north-westerlies are therefore the primary driver of the local climate, alternating with southerlies deflected through the Cook Strait by the South Island's mountain ranges. North-westerly winds predominate in spring and summer, while southerlies dominate in winter. Typically, wind speeds in Wellington vary from 2 m/s to 12 m/s (light breeze to strong breeze), rarely exceeding 17 m/s (high wind) with the highest average wind speed of around 8m/s generally occurring in October, where daily maximums can reach 12m/s (WeatherSpark, 2012).

Summer monthly mean air temperatures in Wellington typically peak at 17.2°C in February, but the highest temperature has been recorded at 31.1°C. Winter monthly mean air temperatures dip to a minimum of 8.9°C in July. Mean monthly humidity peaks in July and reaches its minimum in November. Mean monthly rainfall, humidity, and temperature and mean total annual rainfall for Wellington are presented in *Table 4.1*.

*Table 4.1: Mean Monthly Weather Parameters at Wellington, Indicative for PEP 54858 and 54861*

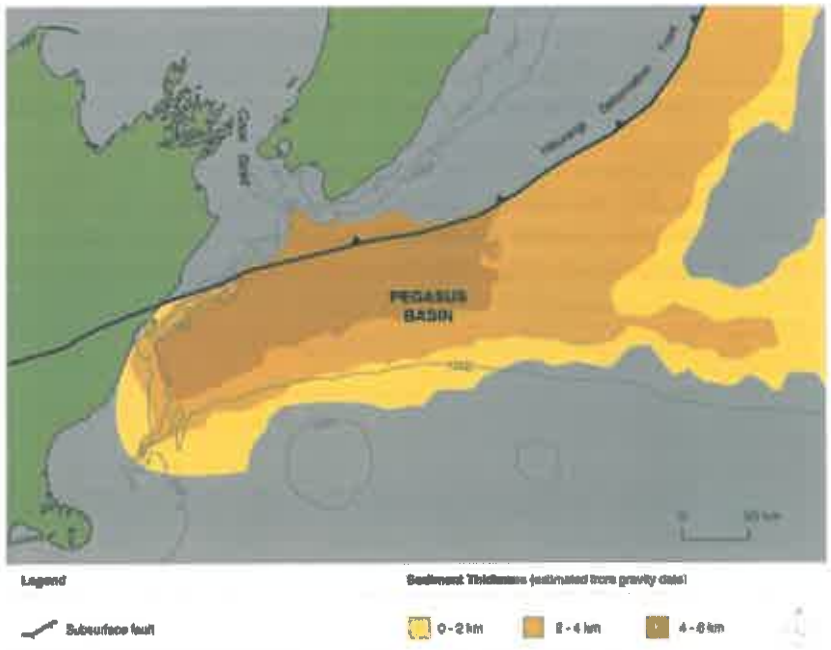
| Parameter | Jan | Feb | Mar | Apr | May | Jun |
|---|---|---|---|---|---|---|
| Rainfall (mm) | 75.7 | 69.8 | 87.1 | 83.6 | 112.9 | 132.8 |
| Humidity (%) | 81.0 | 83.3 | 82.6 | 83.2 | 85.2 | 86.1 |
| Temperature (°C) | 16.9 | 17.2 | 15.8 | 13.7 | 11.7 | 9.7 |
| **Parameter** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| Rainfall (mm) | 137.5 | 113.7 | 97.8 | 114.9 | 97.0 | 84.4 |
| Humidity (%) | 86.3 | 84.7 | 80.8 | 81.3 | 79.7 | 80.7 |
| Temperature (°C) | 8.9 | 9.4 | 10.8 | 12.0 | 13.5 | 15.4 |

*Source: NIWA, no date, accessed 2013*

### 4.1.2 *Geology and Oceanography in the Project Area*

The Pegasus Basin lies east of Wairarapa, Cook Strait and Marlborough. It is adjacent to the transition zone between the highly compressive East Coast ocean-to-continent subduction margin and the continent-to-continent strike-slip margin of Marlborough and central South Island. The southern boundary of the basin is the ancient Gondwana subduction margin along the north flank of Chatham Rise. The northern and eastern limits remain poorly defined. The basin-fill lies across the thickened Pacific Ocean crust of Hikurangi Plateau and laps onto Chatham Rise (NZ Petroleum and Minerals, 2012).

Cretaceous half-grabens along the crest of the Chatham Rise include Late Cretaceous coastal plain and marine facies and there may also be paralic deposits along the northern flank within Pegasus Basin. Cretaceous and Paleogene marine shales are likely to be present and they are inferred to have been buried deeply enough to reach maturity over an area of about 6,000 km². Oil seeps are present in the Cretaceous and Tertiary succession of Marlborough suggesting a nearby active petroleum system (NZ Petroleum and Minerals, 2012).



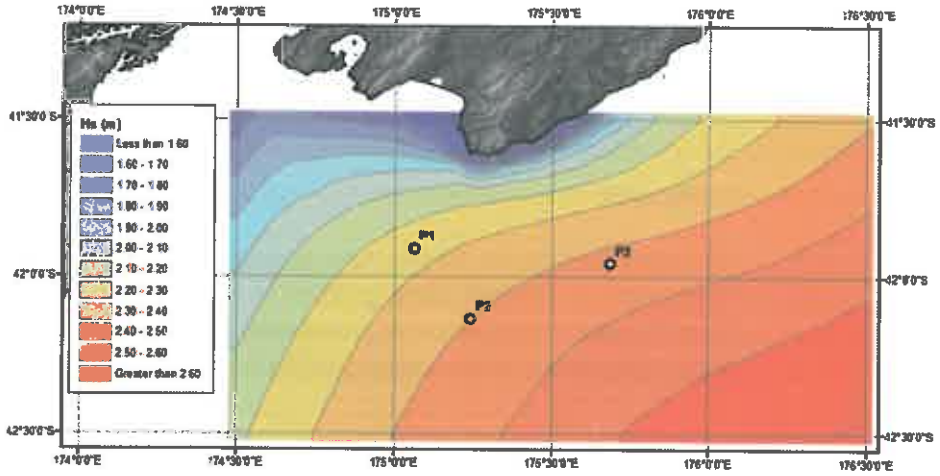

*Source: NZ Petroleum and Minerals, 2012*

*Figure 4.1: Pegasus Basin Map and Bathymetry*

### 4.1.3 *Wave Height*

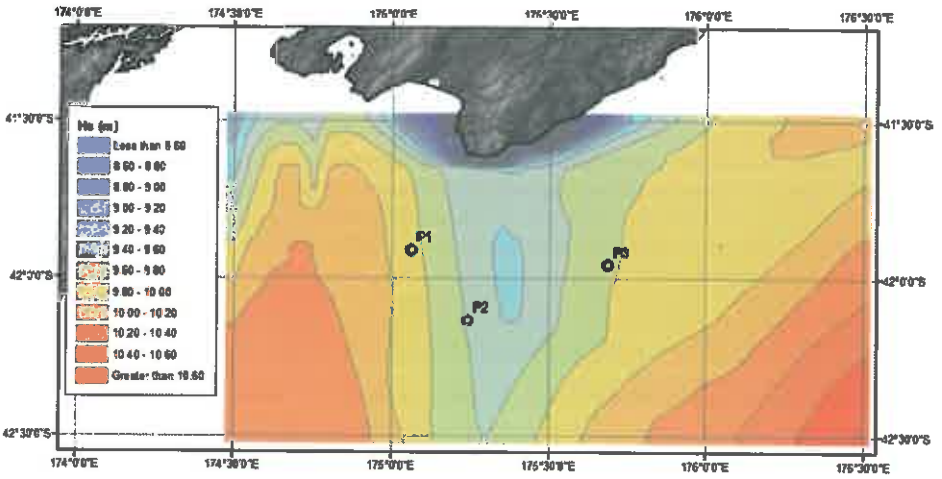
MetOcean Solutions Ltd (**MetOcean**) was engaged by Anadarko to prepare a desktop review of the MetOcean conditions in the Pegasus Basin (MetOcean, 2013).

A variety of numerical hindcast data were used to characterize the wave, wind and ocean current regime at three representative locations in the Pegasus Basin (P1, P2 and P3). The mean significant wave height is illustrated in *Figure 4.2*, showing a height gradient from the southeast to the northwest of the Pegasus Basin, with values between 2.25-2.50 m for the representative hindcast locations. The maximum and the annual mean of maximum significant wave height over the period 1979-2011 are illustrated in *Figure 4.3* and *Figure 4.4* respectively. Significant wave heights can exceed 10 m on the east and west of the Pegasus Basin (*Figure 4.3*). However, the annual mean of maximum significant wave height (*Figure 4.4*) has a well-defined gradient running from the east to the west. Predominantly, there is a higher occurrence of extreme events on the eastern side of the Basin.



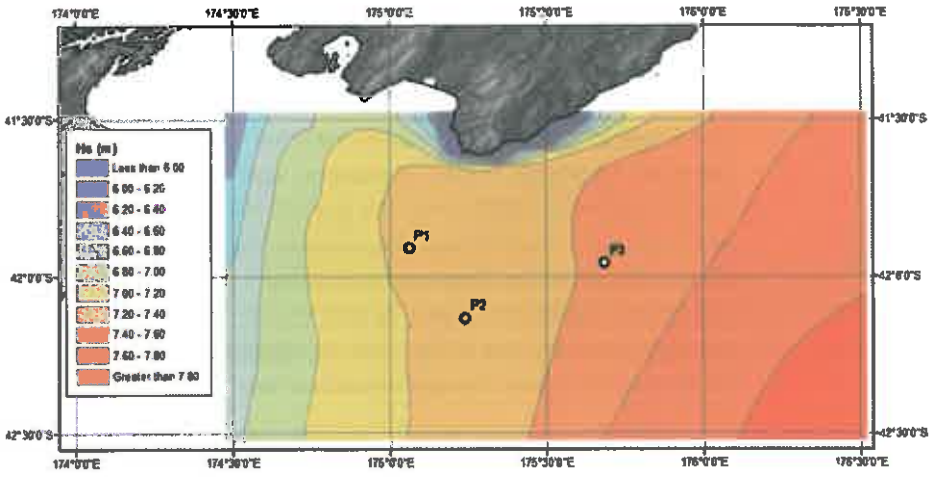

*Source: MetOcean 2013*

*Figure 4.2: Mean Significant Wave Height (1979-2011)*




*Source: MetOcean 2013*

*Figure 4.3: Maximum Significant Wave Heights (1979-2011)*




*Source: MetOcean 2013*

*Figure 4.4: Annual Mean of Maximum Significant Wave Height (1979-2011)*

### 4.1.4 Bathymetry

The bathymetry of the Project Area is presented in *Figure 4.1* and *Figure 4.5*. These show a relatively steep gradient in the northwest of the Project Area from the shallowest point at approximately 100 m depth to the 2,000 m water depth characteristic of the majority of the Project Area.

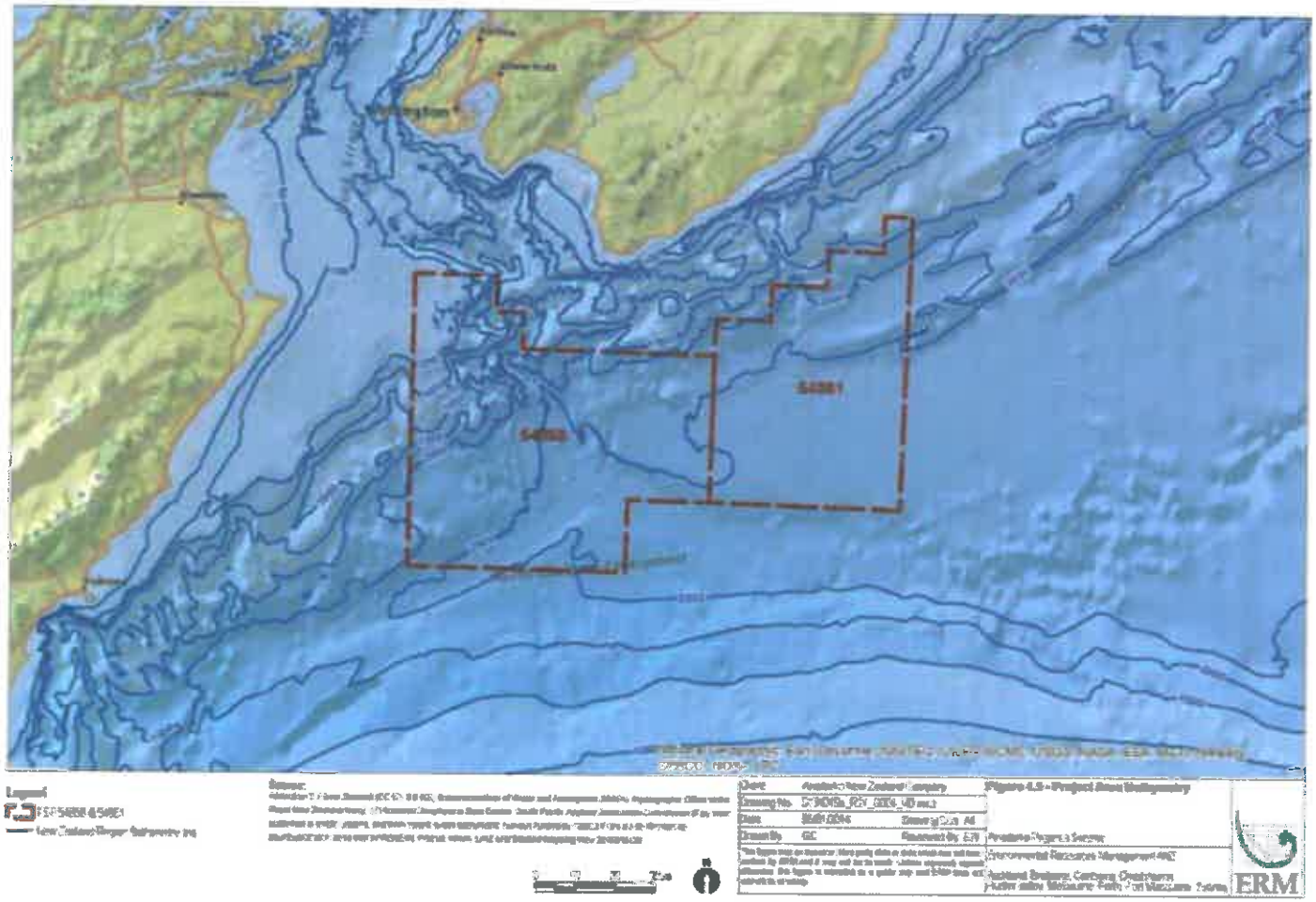
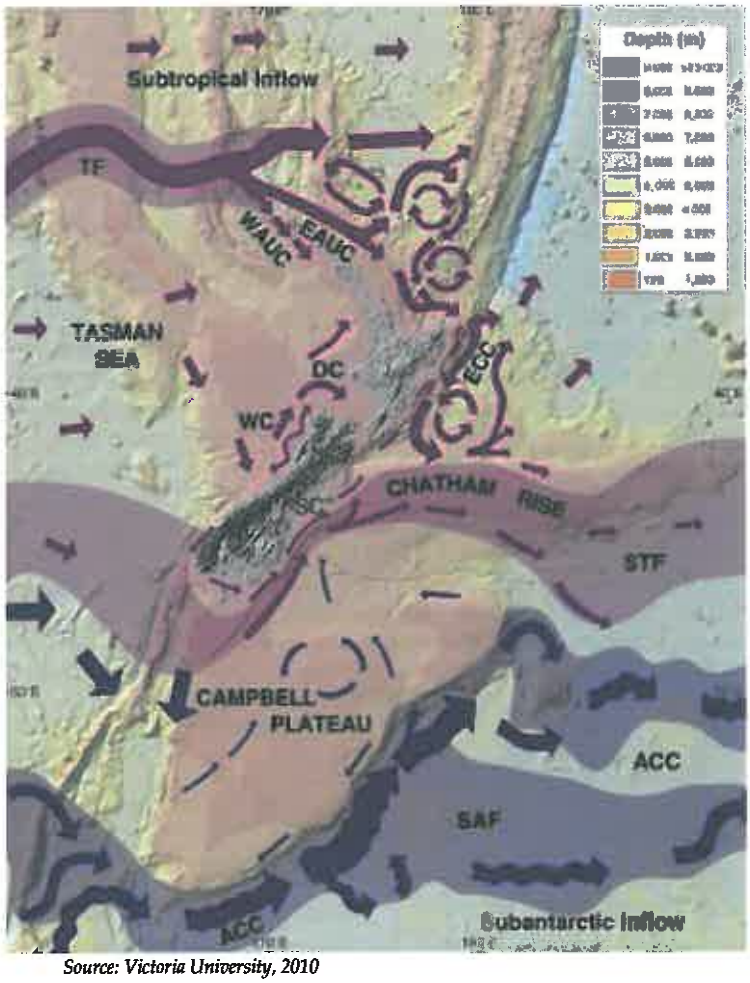



*Figure 4.5: Project Area Bathymetry*

### 4.1.5 *Wind Climate and Currents*

NZ sits in the generally eastward-forward southern branch of the South Pacific subtropical gyre. This gyre is driven by winds – the southeast trade winds to the north, and the Roaring Forties westerly winds to the south. Together these winds set up the anti-clockwise circulation within the gyre, which is then modified by the spin of the earth (*Figure 4.6*).

The coastal current system in NZ is driven by three major oceanic surface current systems – the Tasman Current, West Wind Drift (south of the subtropical convergence zone which lies immediately east of the Project Area) and the Trade Wind Drift. Within the Project Area, it is the D'Urville Current, a branch of the Westland Current travelling west to east through the Cook Strait, and the Canterbury Current, containing water from the Southland Current, together with Sub-Antarctic Water of the West Wind Drift that determine the primary flow. Brodie (1960) notes that drift cards dropped outside Pegasus Bay have travelled as far north as Gisborne.

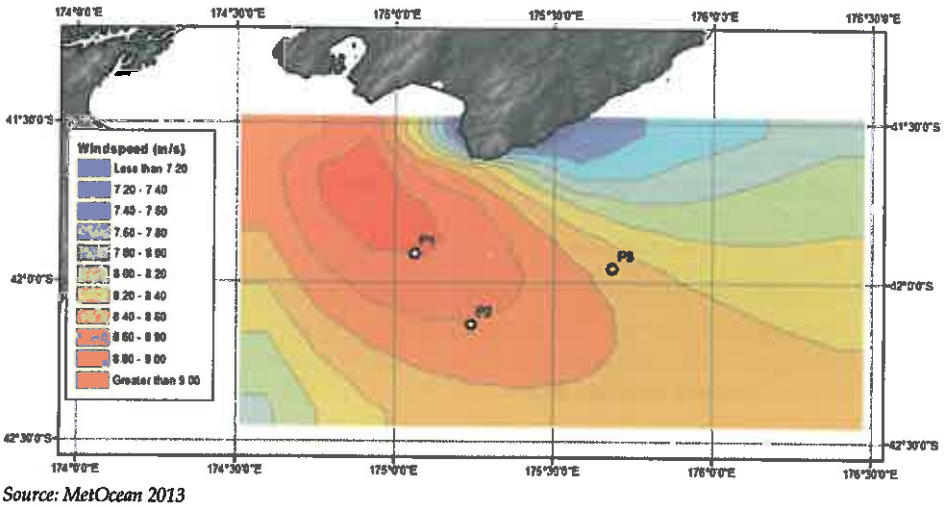



*Source: Victoria University, 2010*

*Figure 4.6: Bathymetry Map Depicting Major Currents Surrounding NZ*

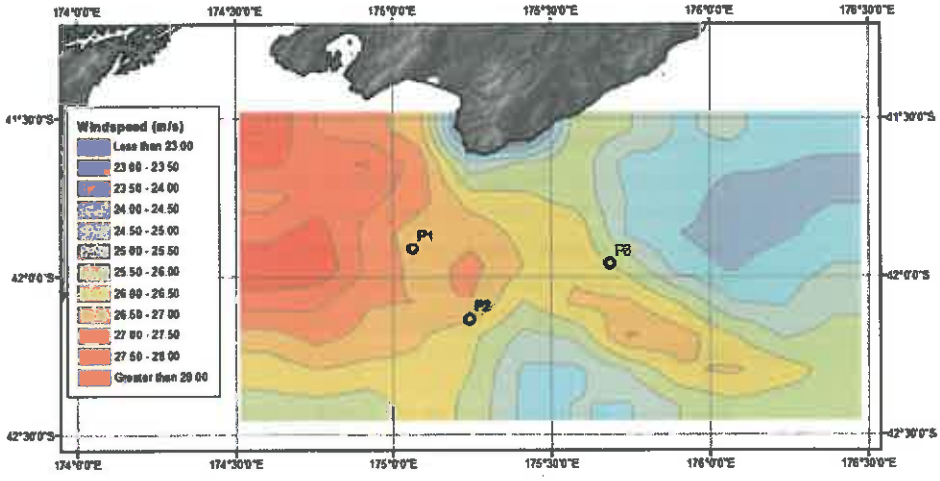
MetOcean provides specific data on wind and current speeds in the Pegasus Basin (MetOcean, 2013). The mean wind speed is illustrated in *Figure 4.7*, showing a speed gradient from the west to the east of the Pegasus Basin. The maximum wind speed over the period 1979-2011 is provided on *Figure 4.8*, showing a similar gradient. This observed gradient is due to the topographic acceleration of the air flow through the Cook Strait. Annual wind speed at locations P1 to P3 are depicted in *Figure 4.9*, *Figure 4.10* and *Figure 4.11*. These show that annual wind speed ranges from 8.48 meters per second (m/s) at P3 to 8.97 m/s at P1. The annual predominance of wind comes from the north-west sector, with an increase of south-west sector winds during the winter months.

The mean current speed at 10 m below sea surface is provided in *Figure 4.12*, showing typical values of 0.18-0.20 m/s at the representative hindcast locations (P1, P2 and P3) while stronger currents were observed on the northern regions of the Pegasus Basin, due to strong flows through the Cook Strait and in the vicinity of Cape Palliser. The maximum current speed over the period 1979-2011 is illustrated in *Figure 4.13*, and shows that P3 is generally more exposed to strong currents than locations P1 and P2. MetOcean reports a relatively strong flow directed to the southwest (approximately 0.25 m/s) at 1000 m below sea level and a local eddy located on the immediate north of location P1. More complex current patterns are observed at 2000 m, with a general southwest flow through sites P1 and P2.



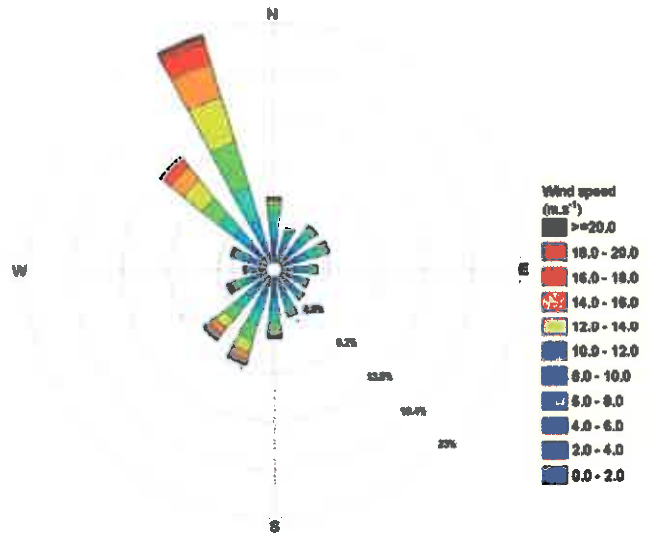

*Source: MetOcean 2013*

*Figure 4.7: Mean Wind Speed (1979-2011) in the Pegasus Basin*




*Source: MetOcean 2013*

*Figure 4.8: Maximum Wind Speed (1979 – 2011) in the Pegasus Basin*




*Source: MetOcean 2013*

*Figure 4.9: Annual Wind Rose at P1. Sectors Indicate the Direction from which Wind is Coming*

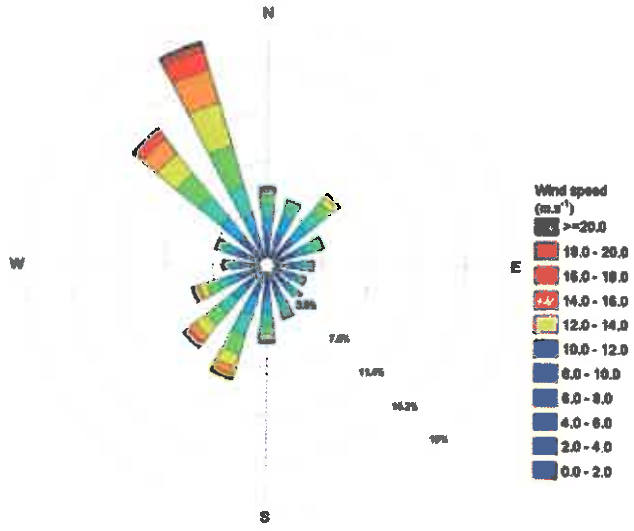



*Figure 4.10: Annual Wind Rose at P2*

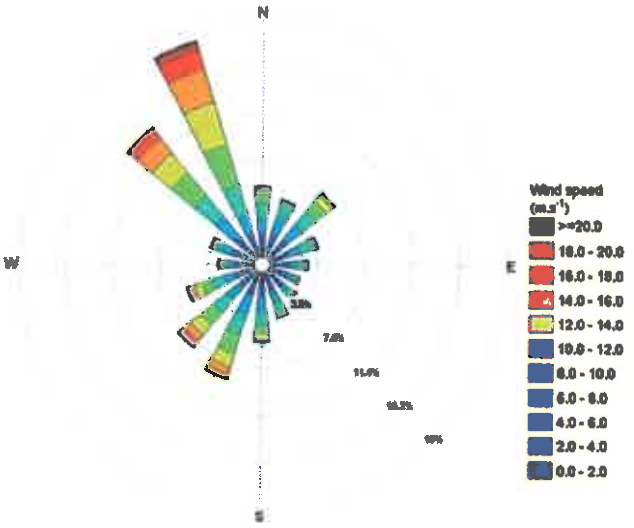
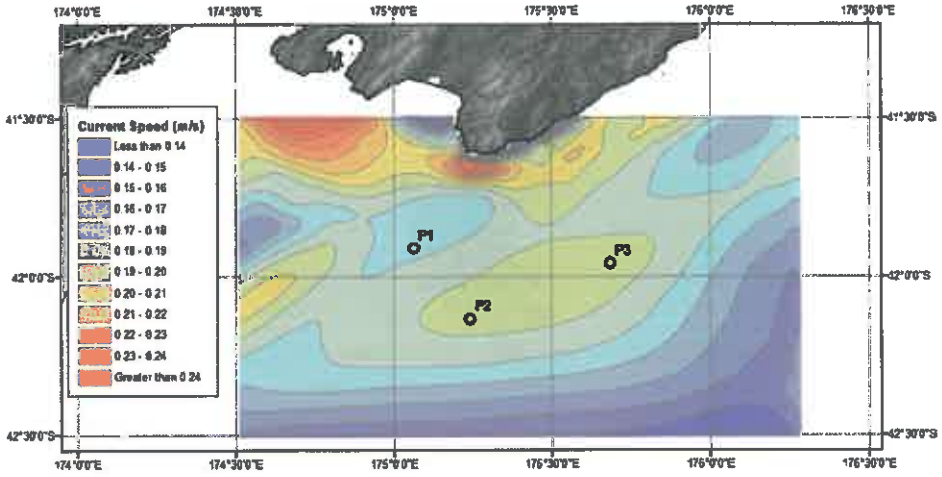
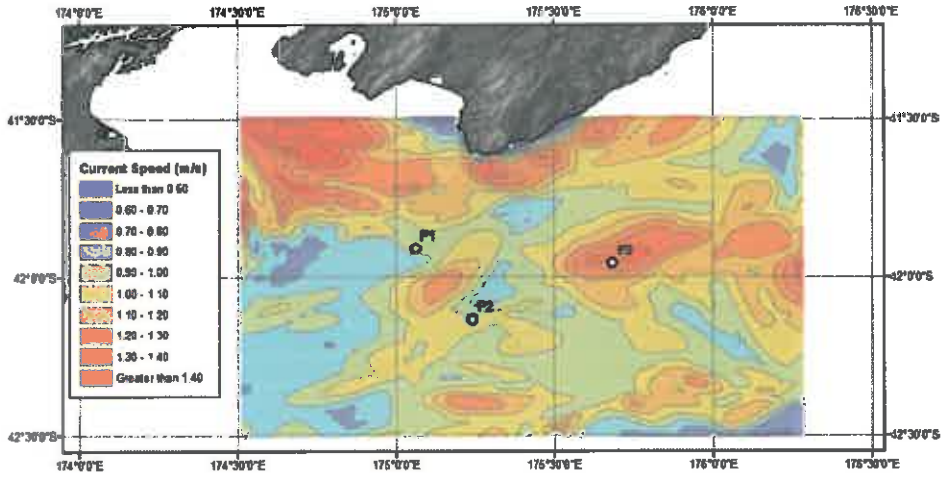



*Figure 4.11: Annual Wind Rose at P3*




*Source: MetOcean 2013*

*Figure 4.12: Mean Current Speed at 10m below Surface (1979 – 2011)*




*Source: MetOcean 2013*

*Figure 4.13: Maximum Current Speed at 10m below Surface (1979 – 2011)*

## 4.2 BIOLOGICAL ENVIRONMENT

The following sections provide detail on the ecosystems, communities and habitats that exist within the deep sea environment of the Project Area.

### 4.2.1 NZ Marine Environmental Classification

NIWA was commissioned by the MfE, MPI and DOC to develop an environmental classification covering NZ's Territorial Sea and Exclusive Economic Zone (**EEZ**), known as the New Zealand Marine Environment Classification (**NZMEC**). The classification provides spatial frameworks for structured and systematic management by subdividing the geographic domain into units having similar environmental and biological character (NZMEC, 2005).

A number of biological and physical factors have been utilized by the MfE (2005) to classify, map and group the features of the marine environment surrounding NZ's coast. The Project Area falls within two boundary groups: 47 and 63. These classifications are explained below:

Class 47 – occurs extensively in deep waters (with a mean depth of 2998 m) over a latitudinal range from around 37–47°S. Average chlorophyll-*a* concentrations within this area are moderately low. Characteristic fish species include the smooth oreo, Baxter's lantern dogfish, the rattail, Johnson's cod and orange roughy.

Class 63 – is extensive on the continental shelf including much of the Challenger Plateau and the Chatham Rise. Waters are of moderate depth (with a mean depth of 754 m) and have moderate annual radiation and wintertime sea surface temperature. Average chlorophyll-*a* concentrations are also moderate. Characteristic fish species include the orange roughy, Johnson's cod, Baxter's lantern dogfish, hoki, smooth oreo and javelin fish. The most commonly represented benthic invertebrate families are Carditidae, Pectinidae, Dentaliidae, Veneridae, Cardiidae, Serpulidae and Limidae.

### 4.2.2 Plankton, Benthic, and Fish Communities

Over 16,000 marine species have been identified in the NZ Marine Fisheries Waters (EEZ and Territorial Sea) (MPI, 2008a). This section provides an overview of the plankton, nekton, and benthic communities in the Project Area.

#### *Plankton*

Plankton can be broadly described as any organisms within the water column that cannot swim against the flow of water (Castro & Huber, 2005). Such species include algae (phytoplankton), animals (zooplankton) and bacteria (bacterioplankton), all of which contribute significantly to the food chain of oceanic ecosystems.

The abundance of phytoplankton provides an indication of the overall levels of productivity within a particular area. Chlorophyll-*a* concentrations at the surface of the water column can be used to infer phytoplankton abundance. Concentrations of Chlorophyll-*a* are reported to range from moderate to moderately low in the Project Area (MfE, 2005), suggesting that productivity levels are relatively low.

Warm subtropical surface waters surrounding the North Island and west coast of the South Island meet colder sub-Antarctic surface waters surrounding the rest of the South Island and offshore islands to the south and east. Here, nutrient rich waters from the south mix with the warmer northern waters to create the Subtropical Front, an ocean feature that circles the Southern Hemisphere (MPI, 2007). The primary area of this convergence is the Chatham Rise, NZ's most productive and important fishing ground. The northern slope of the Chatham Rise is located around 40 km's to the south of the Project Area and comprises a shallow (350-500 m deep) raised area extending eastwards from Banks Peninsula as far as the Chatham Islands. It drops off sharply to great depths of up to 3000 m on the northern and southern flanks of the Chatham Rise. This is a particularly significant area for oceanic productivity (Hadfield, Rickard & Uddstrom, 2010), including for plankton and the animals (fish, baleen cetaceans) that feed on these.

### 4.2.3 *Commercially Fished Species*

Over 1,000 species of fish are known to occur in NZ waters (Te Ara, 2009a), and approximately 130 of these species are commercially exploited in NZ's EEZ (MPI, 2008a).

Deepwater fisheries, which occur in the Project Area, contribute 70% of NZ's total fish catch. In 2012, data were reported by MPI on the status of 163 stocks out of a total of 348 stocks managed under NZ's Quota Management System (QMS). In 2012, the following 21 stocks were considered to be overfished (below the soft limit, or the lower boundary of the desirable population size):

- Southern bluefin tuna (a highly migratory species present seasonally in NZ waters);
- Three stocks of black cardinalfish;
- Five stocks of bluenose;
- Six stocks or sub-stocks of orange roughy;
- Two stocks or sub-stocks of scallops; and
- One stock or sub-stock each of paua, rock lobster, snapper and rig.

Both the orange roughy and black cardinal fish are found within the Project Area and are more detailed below.

Rebuilding programs or Total Allowable Catch (**TAC**)/TACC reductions are in place in these fisheries to allow them to rebuild to target levels (MPI, 2013a).

The Project Area spans across three MPI fisheries regions – Fisheries Management Area (**FMA**) FMA2 Central (East), FMA3 South-East (Coast) and FMA4 South-East (Chatham Rise) (MPI 2013b).

FMA2 extends from the top of East Cape to Tatahi Bay, covering an area of 459,000 km$^2$. The region is home to the tribes of Te Whanau a Apanui, Ngati Porou, Rongowhakaata, Aitanga a Mahaki, Ngai Tamanuhiri, Rongomaiwahine, Ngati Kahungunu, Rangitane, Ngati Toa, Te Atiawa, Muauupoko and Ngati Raukawa. These tribes maintain their hapū mana moana and rangatiratanga over their fishing taonga (MPI, 2013n). Many species within the region hold significant value to Māori, including paua, rock lobster, kina, tarakihi, kahawai, flatfish, freshwater eels, pipi and cockles (MPI, 2013n). Recreational fishing is also important within the region, with a number of sport fishing, surf casting and boating clubs utilizing the area. This area also provides habitat for a number of protected marine species such as fur seals, seabirds and dusky dolphins (MPI, 2013n).

FMA3 covers an area of 205,000 km$^2$ and includes three main fishery areas: Kaikoura, Canterbury and Otago (MPI, 2013p). This area supports rocky reef systems and kelp forests. The Southeast Region covers the traditional landing places of the Uruaokapuarangi, Arai-te-Uru and Takitimu waka hundreds of years ago (MPI, 2013p). Culturally significant species within this area include freshwater eels, paua, rock lobster, kina, and cockles. Recreational fishing within this area is very popular with surfcasting competitions held along the Canterbury coasts during summer (MPI, 2013p).

FMA4 includes the Chatham Islands, a unique and geographically isolated location. This FMA covers an area of 426,000km$^2$. Most Chatham Islanders have Māori/Moriori ancestry or Māori/Moriori family members and so fisheries within this FMA can be thought of as having a very strong customary element (MPI, 2013o). Significant species within this area include paua, kina, rock lobster, blue cod, butterfish, tarakihi and hāpuku/bass. The Chatham island area is becoming more popular with recreational fisheries with charters available to and from the islands (MPI, 2013o). The Chatham Islands provide important habitat to a vast number of marine species including turtles, whales and dolphins.

The estimated catch of the top five species reported in the vicinity of Project Area by volume is summarized in *Table 4.2*, while *Table 4.3* and *Table 4.4* show the number of fishing events by method and target species (MPI, 2013c). Hoki is the species fished in the greatest volume; it is also the species that is most often targeted in the Project Area. Trawling is the most common fishing method used in the Project Area, while bottom long-lining is also undertaken, to a lesser degree (MPI, 2013c).

*Table 4.2: Estimated Catch of the Top Five Species in the Project Area during the 2007/08 – 2011/12 Fishing Years (tons)*

| Species | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | Total |
|---|---|---|---|---|---|---|
| Hoki | 1,152 | 542 | 406 | 539 | 348 | 2,988 |
| Alfonsino | 118 | 57 | 70 | 82 | 53 | 379 |
| Cardinal fish | 108 | 91 | 4 | 23 | 15 | 243 |
| Hake | 1 | <1 | 4 | 220 | <1 | 225 |
| Orange roughy | 35 | 34 | 18 | 29 | 12 | 126 |
| Others | 244 | 104 | 59 | 114 | 80 | 601 |
| Total | 1,658 | 828 | 561 | 1,007 | 508 | 4,562 |

*Source: MPI 2013c*

*Table 4.3: Number of Fishing Events in the Survey Area by Method during the 2007/08 – 2011/12 Fishing Years*

| Method | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | Total |
|---|---|---|---|---|---|---|
| Trawl | 233 | 140 | 125 | 182 | 126 | 806 |
| Bottom longline | 43 | 12 | 11 | 57 | 22 | 145 |
| Total | 276 | 152 | 136 | 239 | 148 | 951 |

*Source: MPI 2013c*

*Table 4.4: Number of Fishing Events in the Project Area by Target Species during the 2007/08 – 2011/12 Fishing Years*

| Target species | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | Total |
|---|---|---|---|---|---|---|
| Hoki | 168 | 108 | 84 | 93 | 75 | 528 |
| Tarakihi | 29 | 9 | 19 | 31 | 35 | 123 |
| Ling | 39 | 11 | 9 | 51 | 6 | 116 |
| Orange roughy | 33 | 21 | 18 | 30 | 13 | 115 |
| Others | 7 | 3 | 6 | 34 | 19 | 69 |
| Total | 276 | 152 | 136 | 239 | 148 | 951 |

*Source: MPI 2013c*

*Figure 4.14* and *Figure 4.15* show the distribution of trawling and bottom long-lining events throughout the year. *Figure 4.14* indicates that in general most trawling takes place between January and June with activity decreasing significantly between July-September. *Figure 4.15* indicates that in most years the majority of bottom long-lining occurs between June-August, but activity can occur at any time of the year.

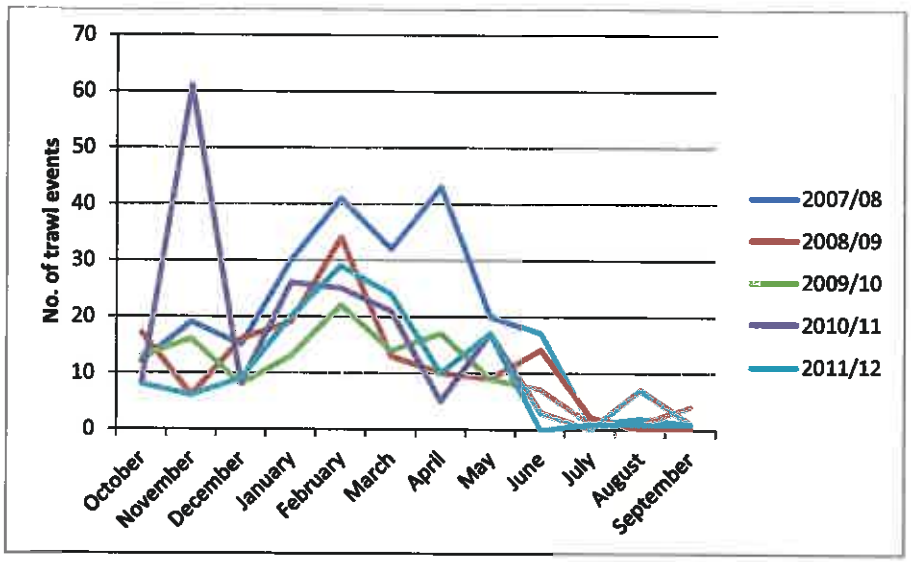



*Figure 4.14: Number of Trawl Events in the Survey Area by Month for the 2007/08 – 2011/12 Fishing Years*

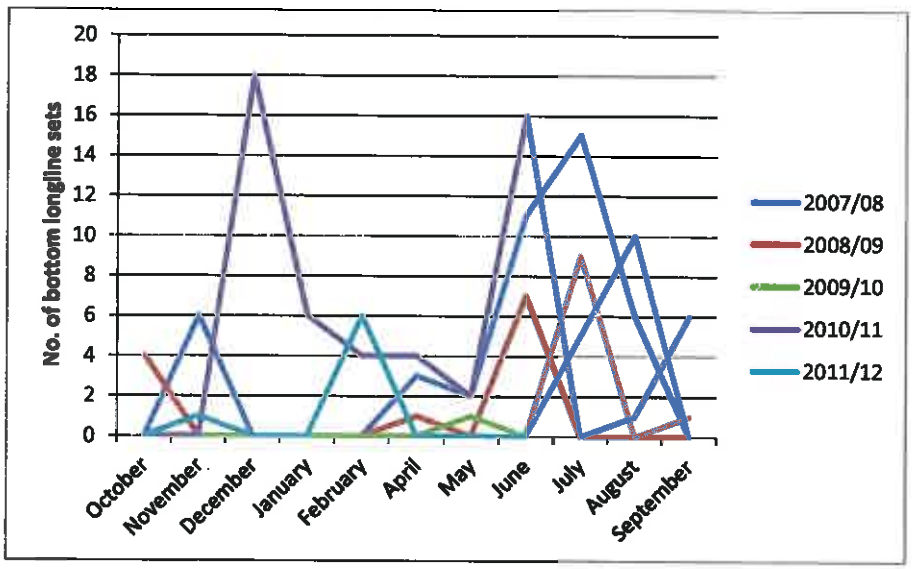



*Figure 4.15: Number of Bottom Long-line Sets in the Survey Area by Month for the 2007/08 – 2011/12 Fishing Years*

The number of fishing vessels that have fished in the vicinity of the Project Area is shown in *Table 4.5* below. This table shows that between 14 and 20 fishing vessels have undertaken at least one fishing event in the Project Area during the past five fishing years.

*Table 4.5:* *Number of Fishing Vessels that Reported At Least One Fishing Event in the Survey Area during the 2007/2008 – 2011/2012 Fishing Years*

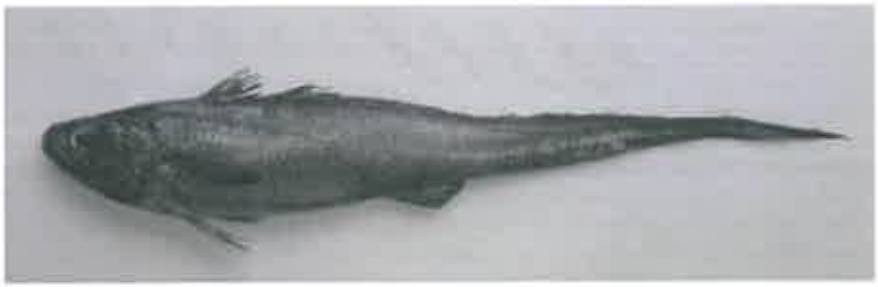
| | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 |
|---|---|---|---|---|---|
| Number of fishing vessels that undertook at least one fishing event in the survey area | 20 | 14 | 14 | 18 | 15 |

The life histories of the top five species caught in the Project Area, as well as those species most commonly targeted, are summarized below.

- hoki (*Macruronus novaezelandiae*);
- alfonsino (*Beryx splendens, B. decadactylus);*
- black cardinal fish (*Epigonus telescopus);*
- hake (*Merluccius australis*);
- orange roughy (*Hoplostethus atlanticus*);
- tarakihi (*Nemadactylus macropterus);* and
- ling (*Genypterus blacodes*).

*Hoki*

Hoki have a maximum age of 20-25 years with males reaching maturity at 60-65 cm length and females at 65-70 cm. Hoki (*Figure 4.16*) are found around Stewart and Snares Shelves, over the sub-Antarctic and the Chatham Rise and occasionally around the North Island. Spawning takes place from late June to mid-September, primarily off the east coast of NZ (including the Project Area). Hoki inhabit depths of 10-900 m, but are most commonly found at depths of 200-600 m (MPI, 2013d).



*Source: www.deepwater.co.nz*

*Figure 4.16:* *Hoki*

*Alfonsino*

Alfonsino are found mostly in central and northern regions. They inhabit seamount areas at depths of 180-1000 m and feed on plankton. Alfonsino (*Figure 4.17*) can reach a maximum age of 17 years, with sexual maturity reached at 4-5 years. No information on spawning in NZ is available but based on international data spawning is reported to occur during summer and autumn (MPI, 2013e).

*Source: http://www.mar-eco.no/gallery/fishes/Beryx_decadactylus_Alfonsino_Ph_JDM_Gordon. Photographer: J.D.M Gordon*

*Figure 4.17: Alfonsino*

*Black cardinal fish*

The black cardinal fish (*Figure 4.18*) occurs throughout the EEZ at depths of 300 – 1100m, mostly in mobile schools up to 150 m off the sea floor, over hills and rough ground. This species is relatively slow-growing and long lived, reaching a maximum age of over 100 years. Spawning is thought to occur in May – June, with fish becoming sexually mature at approximately 35 years (MPI, 2013f). Large spawning aggregations can form typically at depths of 700-800 m throughout the northern part of the EEZ, and is associated with topographic features such as rises, knolls, and seamounts. Spawning grounds have been associated with such topographic features in the Bay of Plenty and off the east coast of the North Island (e.g. Tuaheni High, Ritchie Banks). The status of spawning grounds off Kaikoura and the Challenger Plateau is uncertain (MPI, 2013m).


*Source:http://www2.nabis.govt.nz/LayerDetails.aspx?section=Summary&layer=Annual%20spawning%20distribution%20of%20Black%20cardinal%20fish. Photographer: P McMillan*

*Figure 4.18: Black Cardinal Fish*

*Hake*

Hake are distributed over the length of NZ waters. The species has a maximum age of 25 years. Maturity is reached between 6 to 10 years of age and lengths of 67-75 cm and 75-85 cm, for males and females respectively. Spawning takes place from June to September, but varies depending on area. Spawning locations include areas off the east and south coast of the South Island, spanning as far as the Chatham Islands, and a smaller area off the west coast of the South Island. No spawning occurs within the Project Area. Hake (*Figure 4.19*) are found throughout NZ at depths of 400-1100 m and their diet consists of other fish (MPI, 2013g).

*Source: http://www.unitedfisheries.co.nz/content/hake-merluccius-australis*

*Figure 4.19: Hake*

*Orange roughy*

Orange roughy is an abyssal fish, inhabiting depths around NZ from 700 m to at least 1500 m. Their maximum depth range is unknown. Orange roughy (*Figure 4.20*) are very slow-growing, long-lived fish, living up to 120–130 years. They reach maturity at 23-31 years old. Spawning occurs once a year between June and early August, throughout NZ waters. They feed on mesopelagic and bathopelagic prawns, fish, squid, mysids, amphipods and euphausids (MPI, 2013h).

*Source: http://orangeroughyinfo.tumblr.com/*

*Figure 4.20: Orange Roughy*

*Tarakihi*

Tarakihi are caught in the coastal waters of the North and South Islands, Stewart Islands and the Chatham Islands, down to approximately 250 m in depth. This species reaches sexual maturity at an age of 4-6 years, with a maximum age of approximately 40 years. Tarakihi (*Figure 4.21*) spawn in summer and autumn in several areas around NZ. Three main areas have been identified – Cape Runway to East Cape, Kaikoura to Pegasus Bay and the west coast of the South Island near Jackson Bay. These locations lie outside of the Project Area (MPI, 2013i).

*Source: http://www.niwa.co.nz/news/tagged-juvenile-tarakihi-to-teach-us-about-nursery-habitats*

*Figure 4.21: Tarakihi*

*Ling*

Ling are widely distributed through the middle depths (200–800 m) off NZ, particularly south of latitude 40°S. Ling (*Figure 4.22*) appear to gather in numerous areas during a protracted spawning season, however this is regionally variable, and generally occurs from early spring through to summer. Spawning grounds include the Chatham Rise to the south of the Project Area. Ling appear to be mainly bottom dwellers, where they feed on crustaceans and other fish; however, they will leave the bottom to feed on hoki during the hoki spawning season. Ling have a maximum age of 30 years (MPI, 2013j).

*Source: http://www.sealord.com/www/environment/fish-species*

*Figure 4.22: Ling*

### *Listed Fish Species*

The NZ Threat Classification System is a national system led by DOC that assesses the risk of extinction faced by NZ species, and incorporates NZ's unique ecological and geographical conditions.

The status of each taxon group is assessed over a 3-year cycle. NZ has 444 threatened marine species under the NZ Threat Classification System List; this list includes 38 species of seaweeds (DOC, 2005), 33 of marine invertebrates (Freeman *et al.*, 2010), and 36 of NZs 109 species of seabirds (Miskelly *et al.*, 2008).

DOC lists 55 species of marine fish as being in gradual decline, sparse, or range restricted. The species most commonly fished in the Project Area (discussed above) are not included on this list. It is likely that a number of non-commercially targeted species which are listed may be present in the Project Area, particularly sharks (discussed below). However, there is currently no comprehensive dataset on the occurrence or distribution of listed fish species within the Project Area.

## 4.2.4 *Sharks*

The NABIS database (MPI, 2013m) identifies 11 shark species with distributions that include the Project Area. Only one of these species, the dark ghost shark (*Hydrolagus novaezealandiae*) (*Figure 4.23*), is endemic to NZ. Two species, the great white and basking sharks, are listed in the category of *gradual decline*, indicating that they are at risk of extinction, but that their population decline rates are slow and long-term (WWF, 2010a).

### *Dark Ghost Shark*

The dark ghost shark is widespread throughout NZ, though uncommon around the North Island, Challenger Plateau and Campbell Plateau (Francis, 2003). This species is found at depths between 30 and 800m, but is most abundant between 150 and 500m over outer continental shelf and upper continental slope over soft sediments (Francis, 2003). This species feeds on benthic invertebrates.

*Source: www.oceaniaseafoods.co.nz*

*Figure 4.23: Dark Ghost Shark*

*Great White Shark*

Great white sharks (*Carcharodon carcharias*) are fully protected in NZ waters under the Wildlife Act 1953. It is illegal to hunt, kill or harm them within the 200 nautical miles limit (Patrick, *pers. comm.*). As recently as 2001, great white sharks (*Figure 4.24*) were considered predominantly as an inhibitor of continental and insular shelves, and its migratory habits were virtually unknown (Compagno, 2001). However, satellite tagging research has recently demonstrated that besides spending extended periods of time in preferred coastal areas, great white sharks commonly venture thousands of kilometers into the open ocean (Boustany *et al.*, 2002, Bonfil *et al.*, 2010) and undertake regular long-distance coastal migrations, often returning to sites to which they show a high degree of fidelity (Bonfil *et al.*, 2005, Bruce *et al.*, 2006, Weng *et al.*, 2007, Bonfil *et al.*, 2010).

*Source: http://www.elasmodiver.com*

*Figure 4.24: Great White Shark*

*Basking Shark*

Basking sharks (*Cetorhinus maximus*) are also fully protected in NZ waters under the Wildlife Act 1953. These sharks were often considered to only inhabit shallow coastal waters, with most records of the species collected along the coastlines of temperate countries worldwide (Last and Stevens 2009). Basking sharks (*Figure 4.25*), however, are commonly caught in bottom trawl nets in depths exceeding 700m off the west coast of the South Island (Francis & Duffy 2002, NIWA, 2012), indicating that this species has a much wider distribution that previously thought.

*Source: http://rapgenius.com/8th-harmony-5am-in-toronto-preview-lyrics#note-1610607*

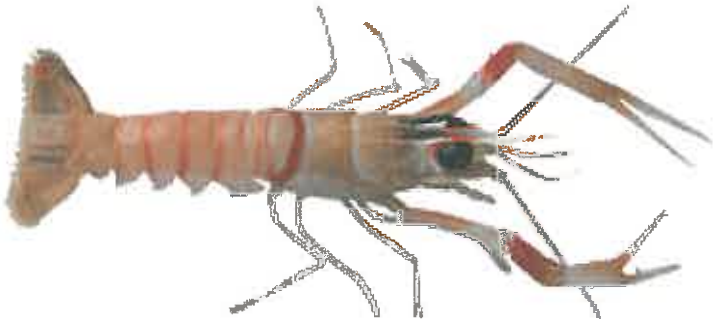
*Figure 4.25: Basking Shark*

### 4.2.5 *Benthic Community*

A comprehensive inventory of the benthic community in offshore NZ is not available, however deepwater commercial fisheries operate within the Project Area, sourcing scampi and deepwater crab. Life histories are provided for these two species.

*Scampi*

Scampi are widely distributed around NZ, principally in depths between 200 m and 500 m on the continental slope. Scampi (*Figure 4.26*) have a maximum age of 15 years. Spawning occurs through spring and early summer. The species is found in sandy and muddy areas of the sea floor, where the scampi make burrows, in which they spend the majority of adult life. The Chatham Rise is identified as one of the main scampi fishery locations, south of the Project Area. Scampi stocks are fished mainly by small vessels (20-40 m) utilizing light bottom trawl gear (MPI, 2013k).



*Source: http://www.deepwater.co.nz/our-species/scampi/*

*Figure 4.26: Scampi*

### *Deepwater Crabs*

Red crab (*Chaceon bicolour*), giant spider crab (*Jacquinotia edwardsii*) and two species of king crab (*Lithodes murrayi* and *Neolithodes brodiei*) are collectively known as deepwater crabs. Deepwater crabs can be found at varying depths down to 1500 m. Of these three, the giant spider (*Figure 4.27*) and king crabs are distributed across the Project Area. Both species of king crab are serial spawners, with spawning occurring in summer or autumn (MPI, 2013l).

*Source: http://www.otago.ac.nz/marinestudies/database/newdatabase/874/index.html*

*Figure 4.27: Giant Spider Crab*

### 4.2.6 *Marine Mammals*

The waters off NZ support a diverse community of marine mammals. Forty-one species of cetaceans (whales, dolphins, and porpoises) and nine species of pinnipeds (seals and sea lions) are known from NZ waters (Suisted and Neale, 2004). A report was produced by NIWA in July 2013 outlining the spatial and temporal distribution patterns of cetaceans with known observation records in or near PEPS 54858 and 54861 (NIWA, 2013). This report provides datasets of 197 sightings of ten different species and one species group (beaked whales) within a 25km buffer of the PEPs.

Eight species of marine mammals identified in NZ waters are included in the NZ Threat Classification List (Baker *et al.*, 2009) as critically endangered, nationally endangered, or range restricted. As a result of the 2008-2011 update, the threat status of the bottlenose dolphin (*Tursiops truncatus*) was up-listed to Nationally Endangered. Four of these listed species have been identified which could be present in the Project Area, due to certain characteristics of their life histories or behaviors:

- Killer whale (*Orcinus orca*) (critically endangered);
- Southern right whale (*Eubalaena australis*) (endangered);
- Bottlenose dolphin (*Tursiops truncatus*) (endangered); and
- Hector's dolphin (*Cephalorhynchus hectori*) (nationally endangered).

The Code lists 36 marine mammals as species of concern. This list is provided in *Table 4.6*, along with detail on which species have been included in this EIA. Justification is provided for those species which have been excluded.

*Table 4.6: Marine Mammal Species of Concern Included or Excluded from this EIA*

| Marine Mammal | Included in the EIA (Y/N) | Justification if species excluded from this of EIA |
|---|---|---|
| Melon-headed whale | N | The Melon-headed whale (*Peponocephala electra*) has a pantropical distribution (Perryman, 2002) within tropical/subtropical oceanic waters between 40°N and 35°S (Jefferson & Barros, 1997). This species range is limited to 500 km north of The southern limit of this species range is approximately 500 km north of the North Island (IUCN, 2008) and is therefore not expected to occur within the Project Area. |
| Pygmy/peruvian beaked whale | N | The distribution of the pygmy beaked whale (*Mesoplodon peruvianus*) is generally unknown. This species has not been documented in NZ waters and only one stranding record exists on the south island (Baker & Van Helden, 1999). This species is therefore not expected to occur within the Project Area. |

| Marine Mammal | Included in the EIA (Y/N) | Justification if species excluded from this of EIA |
|---|---|---|
| Pygmy killer whale | N | The pygmy killer whale (*Feresa attenuata*) is a tropical/subtropical species, generally found in deep, warm oceanic waters between 40°N and 35°S (Taylor *et al.*, 2008a) . This species is thought to be naturally uncommon (Taylor *et al.*, 2008a). This species is not expected to occur within the vicinity of the project. |
| True's beaked whale | N | This species (*Mesoplodon mirus*) is thought be a deep water pelagic species (Houston, 1990) occurring in the southern Indian Ocean, from South Africa, Madagascar, southern Australia and the Atlantic coast of Brazil (MacLeod *et al.*, 2006). This species is not expected to occur within NZ waters, and therefore is not expected within the Project Area. |
| Maui's dolphin | N | The Maui's dolphin (*Cephalorhynchus hectori maui*) is endemic to NZ and known exclusively from the west coast of North Island, NZ (Ferreria & Roberts, 2003). This species is not expected to occur within the Project Area. |
| New Zealand sea lion | N | NZ sea lions (*Phocarctos hookeri*), are an endemic species, with an annual distribution ranging from the southern coast of the South Island down and throughout the waters surrounding both the Auckland Islands and Campbell Islands. Breeding areas predominantly occur on the coast of the south island, (MPI 2013m). This species is not expected to occur within the Project Area. |
| Bryde's whale | Y | Not applicable |
| Humpback whale | Y | Not applicable |
| Sperm whale | Y | Not applicable |
| Pygmy sperm whale | Y | Not applicable |
| Dwarf sperm whale | Y | Not applicable |
| Southern right whale | Y | Not applicable |
| Pygmy right whale | Y | Not applicable |
| Blue whale | Y | Not applicable |
| Pygmy blue whale | Y | Not applicable |
| Sei whale | Y | Not applicable |
| Antarctic minke whale | Y | Not applicable |
| Dwarf minke whale | Y | Not applicable |
| Fin whale | Y | Not applicable |
| Gray's beaked whale | Y | Not applicable |
| Arnoux's beaked whale | Y | Not applicable |
| Cuvier's beaked whale | Y | Not applicable |

| Marine Mammal | Included in the EIA (Y/N) | Justification if species excluded from this of EIA |
|---|---|---|
| Strap-toothed whale | Y | Not applicable |
| Blainville's beaked whale | Y | Not applicable |
| Ginkgo-toothed whale | Y | Not applicable |
| Southern bottlenose whale | Y | Not applicable |
| Andrew's beaked whale | Y | Not applicable |
| Hector's beaked whale | Y | Not applicable |
| Shepherd's beaked whale | Y | Not applicable |
| Long-finned pilot whale | Y | Not applicable |
| Short-finned pilot whale | Y | Not applicable |
| Killer whale | Y | Not applicable |
| False killer whale | Y | Not applicable |
| Bottlenose dolphin | Y | Not applicable |
| Hector's dolphin | Y | Not applicable |
| Southern right-whale dolphin | Y | Not applicable |

*Whales*

Some large whales in the Southern Hemisphere migrate south from the Pacific islands to the Antarctic Ocean each summer (November-December) to feed and then return north each winter (May – July) to the Pacific islands to breed (DOC, 2007). The summer migration route typically follows the west coast of NZ down towards Antarctica, while the winter migration route typically passes up along the east coast of the country towards the Pacific islands.

The Project Area falls within the winter migration route, which will not coincide with the proposed timing of the seismic survey in summer (January 2013). Important areas identified for baleen whales include the waters off Kaikoura, Cook Strait, and off the west coast of the South Island (WWF, 2010b).

*Figure 4.28* shows the distribution and migratory patterns of humpback, sperm, Bryde's and southern right whales. The habitat ranges of the humpback and sperm whales include the Project Area; however the southern right whale habitat is limited to coastal areas and the Bryde's whale is limited to the north east of the North Island.


*Source: Te Ara (2009b)*

*Figure 4.28: Humpback, Sperm and Bryde's Whale Distribution in NZ Waters*

*Humpback Whale*

Humpback whales (*Megaptera novaeangliae*) are reported to migrate north to breeding grounds between May and August along the east coast of NZ, with the southern migration down the west coast from September to December. Humpback whales (*Figure 4.29*) are reported to travel south during migration further from shore (down the west coast), and travel north (up the east coast and through the Project Area) closer to shore (Boren, *pers. comm.*). Both the northern and southern migrations follow the same pattern of a gradual increase in the numbers of whales passing through NZ waters, with a peak near the middle of the season. During the northern migration lactating females and yearlings are seen early in the season, followed by immature whales, then mature males and females, and late in the spring pregnant females (Gibbs and Childerhouse, 2000). Four individuals were recorded within the vicinity of the project area (the PEP and 25km buffer) between 2009 and 2012 (NIWA, 2013). Estimated total population size as of 2008 was approximately 60,000 animals (IUCN, 2013). Humpback whales are listed as of least concern by the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List (IUCN, 2013).

*Source: Red Orbit (2012)*

*Figure 4.29: Humpback Whale*

*Bryde's Whale*

Within NZ waters, Bryde's whales are generally only found in northern NZ, primarily around the Bay of Plenty (see *Figure 4.30*).

The identity and number of species in the "Bryde's whale complex" is still unclear. There is an 'ordinary' Bryde's whale, with a worldwide distribution in the Pacific, Indian and Atlantic oceans, which grows to about 14 m in length, and one or more smaller forms which tend to be more coastal in distribution. The taxonomic status of the smaller forms is unclear (IUCN, 2013).

According to IUCN, the Southern Hemisphere stocks of Bryde's whales have not been re-assessed since 1981. At this time the abundance estimates in the Pacific Ocean were: 16,585 (western South Pacific) and 13,194 (eastern South Pacific) (IWC 1981). These estimates were not based on what are currently accepted methods of survey design and analysis.

Migration patterns vary, with populations in subtropical waters reported to make limited migrations in response to movements of prey. Bryde's whales are reported to feed primarily on fish and krill (ARKIVE, 2013).

The Bryde's whale is classified as Data Deficient on the IUCN Red List (IUCN, 2013).

*Source: www.theguardian.com*

*Figure 4.30: Bryde's Whale*

### *Sperm Whale*

Sperm whales (*Physeter macrocephalus*) are globally distributed and have been recorded in NZ waters (refer to *Figure 4.31*). Typical habitats for sperm whales include open ocean environments and areas on the seaward edge of the continental shelf or in the vicinity of deep canyons where depths may reach 3000 m (WWF, 2010c).

NZ waters support both resident and migrating populations of sperm whales. The key area identified for resident sperm whale populations in NZ is the Kaikoura Canyon which lies approximately 80 km to the southwest of the Project Area (WWF, 2010c). The Cook Strait region is also a known area of increased sperm whale presence (NIWA, 2013).

Adult male sperm whales are solitary and females and calves/juveniles travel together in pods (NIWA, 2013). Mating occurs at all times of the year (Berzin, 1971) and may occur within both the Pegasus Basin and Cook Strait as both male and female sperm whales are found to congregate within these areas (NIWA, 2013). Migrating female sperm whales give birth in subtropical or tropical waters between November and March (Bannister *et al.*, 1996).

A total of 52 sperm whale sightings have been recorded within the vicinity of the Project Area between 2009 and 2012, with a peak in sightings observed during the summer months (NIWA, 2013) Sperm whales have also been identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010). The majority of sperm whale sightings within the area were recorded in habitat of high steep slopes, such as canyon edges and shelf breaks (NIWA, 2013). These habitats are believed to provide optimum conditions for prey species such as cephalopods (Berzin 1971, Clarke 1996, Shirihai 2002). Bioluminescent cephalopods can comprise up to 87% of their diet (Clarke, 1980). This species can dive to depths of 300-800m for approximately 40 minutes with some dives recorded to depths of 1000m for up to 90 minutes (Whitehead & Weilgart 2000).

As a result of commercial harvesting, the sperm whale was reduced from an estimated population of 1.1 million globally to today's population of around 100,000 (Taylor, 2008c). This species is listed as Vulnerable by the IUCN Red List (IUCN, 2013).

*Source: www.montereybayaquarium.org*

*Figure 4.31: Sperm Whale*

*Pygmy Sperm Whale*

Pygmy sperm whales (*Kogia breviceps*) are known from the deep waters of the outer continental shelf and beyond in the tropical and temperate waters of all oceans (McAlpine, 2002). The range of this species is poorly known, however it seems pygmy sperm whales prefer more temperate waters than the dwarf sperm whale (*K. sima*). This species is believed to feed in deep water on cephalopods, fishes and shrimps (Santos & Haimovici 2001, McAlpine *et al.*, 1997). Pygmy sperm whales (*Figure 4.32*) often become stranded on NZ's shores, with 242 individuals stranded between 1978 and 2004 (Hutching, 2012a). This species is listed as 'data deficient' by the IUCN Red List (IUCN, 2013).

*Source: cetaceans.tumblr.com*

*Figure 4.32: Pygmy Sperm Whale*

*Dwarf Sperm Whale*

The dwarf sperm whale (*Kogia sima*) is a tropical species generally found over the continental shelf and slope off tropical and temperate coasts (Rice, 1998). This species rarely occurs in NZ, but has been recorded within waters off the North Island (IUCN, 2012) and the only stranding has been recorded in NZ, occurring at Waiwera beach, North of Auckland. The dwarf sperm whale (*Figure 4.33*) is listed as data deficient by the IUCN Red List (IUCN, 2013).

*Source: http://marinebio.org/species.asp?id=327. Photographer: Keith Rittmaster*

*Figure 4.33: Dwarf Sperm Whale*

### *Southern Right Whale*

The southern right whales (*Eubalaena australis*) (*Figure 4.34*) are listed as nationally endangered and are the only baleen whales known to breed in NZ waters. They calve in coastal waters over winter months and tend to migrate offshore to feeding grounds during summer months. The summer feeding grounds of the southern right whales are not well known, however their distribution is likely to be linked to the distribution of their principal prey species which are copepods in the region of the Sub-Tropical Front (41–44°S) and krill at higher latitudes (south of 50°S).

Historical whaling records suggest summer feeding grounds off the Chatham Rise (Patenaude, 2003), which lies to the south and east of the Project Area. Southern right whales are seen around the mainland coastline from May to October each year. Southland and Otago have been identified as areas of 'seasonal' ecological significance by DOC (2006). According to Te Ara (2009b) the southern right whale was once very common around NZ but is now largely confined to the Auckland and Campbell Islands. These whales are, however, slowly expanding their range and recolonizing calving grounds they had once been extirpated from around the mainland, with some of these close to the Pegasus Basin and the Cook Strait (including Wellington harbor) (Carroll *et al.*, 2013).

Southern right whales were identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010) and three individuals were identified within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). Estimated total population size as of 1997 (the last major review by the International Whaling Commission) was 7,500 animals (of which 1,600 were mature females) (IUCN, 2013). Estimates of the NZ population at this time, including the NZ Subantarctic Islands, were of approximately 950 individuals and the population trend was unknown (NOAA, 2012a). Southern right whales are listed as of least concern globally by the IUCN Red List (IUCN, 2013).

*Source: marinesciencetoday.com*

*Figure 4.34: Southern Right Whale*

### *Pygmy Right Whale*

The pygmy right whale (*Caperea marginata*) (*Figure 4.35*) has a circumpolar distribution in temperate waters between 30° and 55°S (Hoffmann and Best 2005). Only a few confirmed records exist of live whales at sea, however, strandings have been recorded from both the North and South Island. (Kemper 2002a,b; Rice 1998). Little is known about the preferred habitat for this species. This species is listed as data deficient by the IUCN Red List (IUCN, 2013).

*Source: press.princeton.edu*

*Figure 4.35: Pygmy Right Whale*

*Blue Whale*

Blue whales (*Balaenoptera musculus*) has four recognised subspecies, including the northern blue whale (*B. m. musculus*), Antarctic or southern blue whale (*B. m. intermedia*), Indian Ocean blue whale (*B. m. indica*) and the pygmy blue whale (*B. m. brevicauda*) (Reilly *et al.*, 2008a). Like many other baleen whales, blue whales (*Figure 4.36*) feed in cool waters at high latitudes and generally migrates to warmer temperate/tropical waters to breed and calve (WWF, 2012). There is growing evidence to suggest that NZ may support a resident population of blue whales, where foraging grounds have been found in the South Taranaki Bight (Torres, 2013) and acoustic recordings demonstrate a year-round presence (Miller *et al.*, 2013). This species is believed to pass through the Project Area during migrations between feeding and breeding grounds. Two sightings of blue whales have been recorded at the western end of the Chatham Rise, in 1984 and 1998. One blue whale was recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). Although the global population is uncertain, the IUCN (2013) estimate that it is likely in the range of 10,000 to 25,000 globally.

Pygmy blue whales (B. m. *brevicauda*) are listed as migrants within NZ waters (WWF, 2013b), and are centered in the Sub-Antarctic Zone of the Indian Ocean between 0°E and 80°E (Cetacean Specialist Group 1996). There is uncertainty about this species abundance and range, with its winter range virtually unknown, with scattered records from South Africa and Australia (Rice, 1998). A beached pygmy blue whale was found in Waitotara in 2011 and therefore this species has the potential to occur within the Project Area.

Under the IUCN Red List, blue whales are listed as Endangered and pygmy blue whales are listed as Data Deficient (IUCN, 2013).

*Source: www.eco-odyssey.com*

*Figure 4.36: Blue Whale*

*Sei Whales*

Sei whales (*Balaenoptera borealis*) (*Figure 4.37*) is a cosmopolitan species comprising two recognized subspecies. In the northern hemisphere, the subspecies *B. b. borealis* exists, while in the southern hemisphere the subspecies *B. b. schlegellii* exists (Reilly *et al.*, 2008c). This species migrates between tropical and subtropical latitudes in winter and temperate and subpolar latitudes in the summer (Reilly *et al.*, 2008c). Sei whales are most generally found in the upper portions of the water column (<300m) and feed on a variety of fish and squid (NIWA, 2013). One sei whale was recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). This species is listed as endangered by the IUCN Red List (IUCN, 2013).

*Source: www.eco-odyssey.com*

*Figure 4.37: Sei Whale*

*Minke Whale*

Globally, there are now two recognized species of minke whale (*Figure 4.38*), the common northern minke whale (*Balaenoptera acutorostrata*) and the Antarctic/southern minke whale (*Balaenoptera bonaerensis*) (NOAA, 2012b). The northern minke is confined to the northern hemisphere. However, a subspecies, the dwarf minke (*B. acutorostrata subsp.*) is often found in NZ. The Antarctic or southern minke whale is confined to the southern hemisphere, including NZ. Compared with Antarctic minke whales, dwarf minke whales are much less common and occur more predominantly at higher latitudes (Reilly, 2008e) and is known from more temperate waters, such as those off the NZ coasts both in and north of the Bay of Plenty (WWF, 2013b). Dwarf minke whales are known to breed within NZ waters (WWF, 2013b).

Antarctic minkes have been observed around the NZ coast, but are reported to be most common south of NZ, feeding in the Antarctic waters (DOC, unknown). There is currently no estimate of total global population size, but regional estimates indicate that the species is well above the threatened species threshold (IUCN, 2013). Antarctic minkes are listed as data deficient whereas the common minke is listed as of least concern by the IUCN Red List (IUCN, 2013).

*Source: http://blog.diversiondivetravel.com.au. Photographer: Rod Klein*

*Figure 4.38: Minke Whale*

### *Fin Whale*

Fin whales (*Balaenoptera physalus*) are a worldwide species, where two subspecies are known. In the northern hemisphere the subspecies *B. p. physalus* exists, while in the southern hemisphere the subspecies *B. p. quoyi* exists (Rice, 1998). Fin whales (*Figure 4.39*) occur in the north Pacific, north Atlantic, Indian and Arctic Oceans, as well as in the Mediterranean (WWF, no date), however fin whales are rare in NZ waters (Hutching, 2012b). They show well defined migratory movements between polar, temperate and tropical waters (Mackintosh, 1965), with the bulk of the fin whale summer distribution in middle latitudes, mainly 40°S-60°S in the southern Indian and South Atlantic oceans, and 50°-65°S in the South Pacific (Miyashita *et al.*, 1996, IWC, 2006). This species is listed as endangered by the IUCN Red List (IUCN, 2013).

*Source: http://blogs.smithsonianmag.com/*

*Figure 4.39: Fin whale*

### *Beaked Whales*

There are twenty six species of beaked whale, with at least twelve of these species known to occur in NZ waters (WWF 2013). An example of a beaked whale (Cuvier's beaked whale) is illustrated in *Figure 4.40*. Little is known about the distribution of beaked whales, and due to limited sightings at sea it is difficult to identify specific habitat types and behaviors for individual species (WWF, 2010d). Most of the data gathered on this species has been collected from strandings, which are also rare. The majority of NZ strandings have occurred within the Bay of Plenty, Chatham Islands and some subantarctic islands (WWF 2013). It has been inferred that most beaked whale species live in small groups in cool, temperate waters, and their preferred habitat is deep ocean waters or continental slopes down to about 200 m. Several species appear to be largely restricted to southern NZ waters (WWF, 2010d), suggesting that these whales do not undertake annual migration. It is possible that beaked whales may be encountered in the Project Area, and one beaked whale was identified within the vicinity of the project area between 2009 and 2012 (NIWA, 2013), however it is uncertain whether the Pegasus Basin is significant habitat for beaked whales.

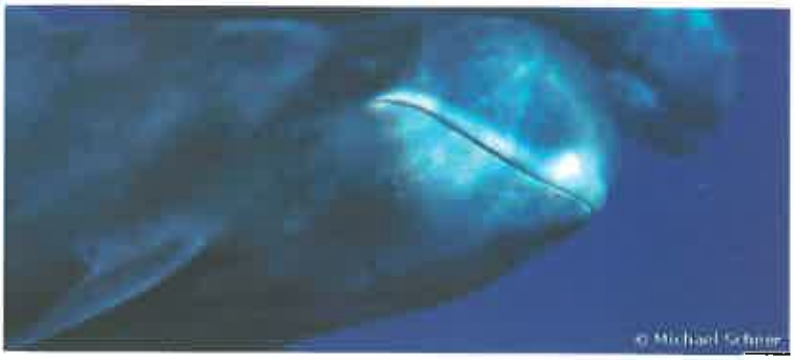
*Source: http://www.arkive.org/cuviers-beaked-whale/ziphius-cavirostris/. Photographer: Todd Pusser*

*Figure 4.40: Cuvier's Beaked Whale*

*Dolphin Family*

*Pilot Whale*

Two species of pilot whale are found within NZ waters, the long-finned pilot whale (*Globicephala melas*) and the short-finned pilot whale (*Globicephala macrorhynchus*). Pilot whales (*Figure 4.41*) prefer waters along the continental shelf break and in areas of sharp topographic relief (WWF, 2010e). Long-finned pilot whales are migratory and feed in off-shore deeper water on fish and squid. Long-finned pilot whales prefer more cold temperate waters to short-finned pilot whales, who are generally found to have a more tropical and sub-tropical distribution. Therefore, it is likely that long-finned pilot whales would be more common within the Project Area than short-finned (NIWA, 2013). Goodall and Macnie (1998) reported that young pilot whales were present in all areas of the South Pacific including the sub-Antarctic, as they were sighted in summer, autumn and spring, when births occurred. These species are highly social, travelling in groups consisting of an average of 20-90 individuals (Olson 2009, Shirihai 2002). Pilot whales were identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010) and a total of 21 individuals were recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). The IUCN Red List classifies both species as data deficient, however the global estimated population is around 750,000 (Taylor *et al.*, 2011). Both species of pilot whales are listed as data deficient under the IUCN Red List (IUCN, 2013).



*Source: http://www.pilot-whales.org/. Photographer: Michael Scheer*

*Figure 4.41: Pilot Whale*

### *Killer Whale*

Killer whales (*Orcinus orca*) are listed as Nationally Critical in the NZ Threat Classification Scheme (Baker *et al.*, 2009) and are likely to be transient species in the Project Area (*Figure 4.42*). Two killer whale populations are reported in NZ waters, one inshore and one offshore, which are yet to be properly verified. Killer whales do not have a known defined migration cycle but appear to travel between preferred habitats in search of seasonally abundant prey (NIWA, 2013). They are reported to be common during the summer NZ fur seal breeding season (Patrick *pers. comm.*) and fur seal colonies are located near to the Project Area at Ohau Point and Cape Palliser (70 km west and 25 km north of the Project Area, respectively). Killer whales are reported to pass through Kaikoura every two-three weeks in summer (approximately 80 km south-west of the Project Area) (DOC, *pers. comm.*).

A total of 23 killer whales were recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). The majority of these sightings were recorded over habitat of steep bathymetric relief associated with canyons and shelf breaks (NIWA, 2013). While global populations of killer whales are uncertain, there is a general consensus that it is a minimum of 50,000 globally, with the majority of this population in Antarctica (IUCN, 2013). Killer whales are listed as data deficient under the IUCN Red List (IUCN, 2013).

*Source: http://www.dominiontours.com/galeria/index.php/Animales-Oeste-de-Canada/Orca-Greeting-by Christina-Craft*

*Figure 4.42: Killer Whale*

### *False Killer Whale*

False killer whales (*Pseudorca crassidens*) are likely to be transient species in the Project Area and are generally found in tropical and temperate waters worldwide (Stacey *et al.*, 1994; Odell and McClune 1999), most commonly in relatively deep, offshore waters (*Figure 4.43*). This species primarily feed on fish and cephalopods, but are also known to attack small cetaceans, humpback whales, and even sperm whales (Taylor *et al.*, 2008d). These species are known for mass strandings with the largest mass stranding documented of over 800 individuals. According to Brabyn (1991), 84% of the individuals stranding are in three species: false killer whales, pilot whales, and sperm whales. False killer whales were identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010). False killer whales are listed as data deficient under the IUCN Red List (IUCN, 2013).

*Source: http://cetus.ucsd.edu/voicesinthesea_org/species/dolphins/falseKiller.html*

*Figure 4.43: False Killer Whale*

*Dusky Dolphin*

The dusky dolphin (*Lagenorhynchus obscurus*) has three subspecies, the South American dusky dolphin (*L. obscurus fitzroyi*), Indian Ocean dusky dolphin (*L. obscurus obscurus*) and an unnamed NZ dusky dolphin (Reilly, 2008; *Figure 4.44*). Calving from November to around mid-January, the Dusky Dolphin has a lifespan of around 30 years (DOC, 2012a). Dusky dolphins are most commonly found in cooler waters in more southerly latitudes of the lower part of the North Island and around most of the South Island (Wursig *et al.*, 2007). They feed in the shallow areas of the water column on small to mid-size fish and squid (NIWA, 2013). Within the vicinity of the Project Area, dusky dolphins show a preference for shallow habitat over the shelf and along the slopes of canyons and shelf breaks (NIWA, 2013).

The Department of Conservation has classified the dusky dolphins to be non-threatened in NZ, with an estimated national population of between 12,000 and 20,000 throughout NZ waters (DOC, 2012a). The IUCN Red List classifies this species as data deficient (Hammond *et al.*, 2008b). With a widespread distribution in the Southern Hemisphere the main near shore concentrations of dusky dolphins NZ occur in Kaikoura and in the Marlborough Sounds (DOC, *pers. comm.*). Dusky dolphins were identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010) and 27 were recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). The National Aquatic Biodiversity Information System (NABIS) includes the Project Area as part of the dusky dolphin full range. The dusky dolphin is listed as data deficient under the IUCN Red List (IUCN, 2013).

*Source: www.scottelowitzphotography.com. Photographer: Scott Elowitz*

*Figure 4.44: Dusky Dolphin*

*Common Dolphin*

Globally, the common dolphin is split into two species, the long-beaked (*Delphinus delphis)* and short beaked (*Delphinus capensis)* (*Figure 4.45*). Short-beaked common dolphins are found in waters throughout NZ and Australia. This species can live up to 35 years of age, reaching maturity between 3 and 12, and calves every 1 to 3 years (NOAA, 2012c). Typically calving occurs every year among the wider population with the 10 -11 month gestation typically beginning around June to September (NOAA, 2012c). This species feeds on a diverse range of fish and cephalopod species including arrow squid, jack mackerel and anchovy (Meynier *et al.*, 2008).

The common dolphin is a highly abundant species with nearly 3 million in the Pacific region alone (Hammond, 2008a). As such, this species is listed as 'least concern' by the IUCN Redlist and in NZ they are not considered to have any conservation or management issues (Hammond, 2008a; Suisted and Neale, 2004). In NZ, the distribution of the common dolphin encompasses most of the North Island, South Island, Stewart Island and Chatham Island coastlines, with dominance in the northern half of the North Island, East Cape, Cook Strait, Marlborough Sounds and northwest coast of the South Island (NABIS, 2013). NABIS includes the Project Area within a 'hotspot' for this species, with a preference for shallower habitats over the shelf and slope areas (NIWA, 2013).

NIWA (2013) observed more sightings of common dolphins within the vicinity of the Project Area in winter and spring, with 16 records each. Fewer sightings were recorded in autumn and summer with 13 and 5 records respectively. Common dolphins were identified on a 2009-10 seismic survey within the Pegasus Basin (MED, 2010) and 62 individuals recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013).

*Source: life-sea.blogspot.com*

*Figure 4.45: Common Dolphin*

*Bottlenose Dolphin*

The common bottlenose dolphin (*Tursiops truncatus*) is listed as Nationally Endangered in the NZ Threat Classification Scheme (Baker *et al.*, 2009) is one of the most widely recognised species of dolphin (Hammond *et al.*, 2012a; NOAA, 2012d; *Figure 4.46*). This species can live for up to 40 or 50 years, reaching sexual maturity ranging from 5 to 14 years of age (NOAA, 2012d). Calving occurs around every 3 to 6 years in this species, peaking in NZ between spring and summer/autumn months (DOC, 2012e).

In NZ this species is found among three main populations. Populations are known off the east coast of the North Island (ranging from Doubtless Bay in the north to Tauranga in the south), in the Doubtless Sound in Fiordland, and another group ranges from Marlborough Sounds to Westport. NABIS includes the Project Area within the 'normal range' for this species (NABIS, 2013) with 12 individuals recorded within the vicinity of the project area between 2009 and 2012 (NIWA, 2013). The majority of these sightings recorded in shallow habitat over steep bathymetric relief associated with canyons and shelf breaks (NIWA, 2013). This species generally feeds in shallower areas of the water column on small to mid-sized fish and squid. The bottlenose dolphin is listed as of least concern under the IUCN Red List (IUCN, 2013).

*Source: http://www.coral.org/_403*

*Figure 4.46: Bottlenose Dolphin*

*Hector's Dolphin*

The Hector's dolphin (*Cephalorhynchus hectori*) is endemic to NZ and has one of the most restricted distributions of any cetacean (Dawson & Slooten, 1988; Dawson, 2002). This species is most commonly recorded off the South Island and the west coast of the North Island (*Figure 4.47*). The closest Marine Mammal Sanctuary (MMS) to the Project Area, the Clifford and Cloudy Bay MMS (over 15 km from the Project Area), is known to be an important area for Hector's dolphin (see *Section 4.2.10* below).

DNA studies on this species identified that the South Island Hector's dolphin is genetically distinct from the North Island sub-species, known as Maui's dolphin. According to Dawson *et al.* (2001), differences over such a small geographic scale have not been observed in any other marine mammal. The population in the South Island is estimated at around 7270 individuals (Dawson *et al.*, 2004; Gormley *et al.*, 2005). A significant population of Hector's dolphin is known to occur around Clifford and Cloudy Bays, at the top of the South Island (Ministry of Fisheries and Department of Conservation, 2007).

Hector's dolphins are found in shallow coastal waters, less than 100 m deep and generally within 15 km of the shore. This species feeds on small fish and squid (Dawson, 2002).

Hector's dolphins are listed as 'endangered' under the IUCN Red List (IUCN, 2013) and as 'nationally endangered' by DOC (DOC, 2005).

*Source: http://cetaceans.tumblr.com/post/2312279606/whale-of-the-day*

*Figure 4.47: Hector's Dolphin*

*Southern Right-Whale Dolphin*

The distribution of the Southern right whale dolphin (*Lissodelphis peroni*) is poorly know, however they appear to be circumpolar and fairly common throughout its range (Jefferson *et al.*, 1994, Lipsky 2002). These dolphins have been studied off Kaikoura (Visser, Fertl & Pusser, 2004). This species inhabits cool temperate and subantarctic waters most commonly between 30° and 65°S (Hammond, 2012b). Southern right whale dolphins (*Figure 4.48*) prefer cool, deep offshore waters and feed primarily on squid and fish (Jefferson *et al.*, 1994). The southern right whale dolphin is listed as data deficient under the IUCN Red List (IUCN, 2013).

**Source:** *animalworld.tumblr.com*

*Figure 4.48: Southern Right Whale Dolphin*

### *Pinnipeds*

#### *NZ Fur Seal*

The NZ fur seal (*Arctocephalus forsteri)* is known to forage along shelf breaks at sea and is likely to be encountered feeding in the Project Area (*Figure 4.49*). During a 2009-2010 seismic survey in the Pegasus Basin, a total of 123 individual fur seals were identified (MED, 2010). Breeding areas predominantly occur on the coast of the South Island, but a small number of breeding areas are known from the North Island, with two occurring directly adjacent to the Project Area (MPI 2013). Adult males arrive at breeding colonies first from late October, followed by females in late November. Pups are born between mid-November and January and weaned in July/August when the females return to sea (DOC, 2012e; MPI 2013). The NZ fur seal is a relatively common species with no significant threat at the wider population level. It is listed as of least concern under the IUCN Red List (IUCN, 2013).

**Source:** *www.newzealandphoto.info*

*Figure 4.49: New Zealand Fur Seal*

### 4.2.7 *Marine Reptiles*

Seven species of marine reptiles are known to occur off NZ's coast. These include the loggerhead turtle (*Caretta caretta)*, the green turtle (*Chelonia mydas)*, the hawksbill turtle (*Eretmochelys imbricate)*, the Olive Ridley turtle (*Lepidochelys olivacea)*, the leatherback turtle (*Dermochelys coriacea*) the yellow-bellied sea snake (*Pelamis platurus)*, and the banded sea snake (*Laticauda colubrine)*. Of these species, four are referenced in the 2005 edition of the DOC Threatened Species list (reptiles were not included in the 2008-2011 update) as vagrant or migrant, due to their status on the IUCN Red List, with the leatherback turtle and hawskbill turtle listed as critically endangered and the green turtle and loggerhead turtle listed as endangered.

With the exception of the leatherback turtle, marine reptiles are characteristically found in warm temperate seas, so most of NZ's marine reptiles are concentrated in the warm waters off the northeast coast of the North Island (WWF, 2010g). Leatherback turtles are the most likely to occur more widely throughout NZ than other species and have been recorded as far south on the west coast of the South Island, as well as records near Otago Peninsula, Banks Peninsula and Kaikoura (WWF, 2010g).

### 4.2.8 *Seabirds*

The marine waters off NZ support a total of 86 species of sea birds, including albatrosses, cormorants and shags, fulmars, petrels, prions, shearwaters, terns, gulls, penguins, and skuas (DOC, 2010b). NZ waters host the greatest variety of albatrosses and petrels in the world, and are an important breeding ground for many of these species.

Most of NZ's seabird species breed on coastal headlands and islands off the NZ coast and some would use the Project Area as foraging habitat. Because many NZ seabirds travel long distances, they face a number of threats while at sea, including interactions with fisheries, pollution and depletion of prey (DOC, 2010b).

There have been a number of measures established by MPI to protect seabirds. These are primarily associated with the reduction of by-catch from the fishing industry and include a number of international obligations, NZ's National Plan of Action for seabirds, and new measures such as MPI seabird standard (MPI, 2008b).

DOC has published a Fisher's Guide to NZ Seabirds (Biswell, 2007). This guide provides information on seabirds that are at risk of being caught in off-shore fisheries. It covers species distributions, land and at-sea threats and risk status, based on the IUCN Red List of threatened species.

Of those species listed as endangered or critically endangered, the Project Area is listed as a 'hotspot' for three species (MPI, 2013):

- Westland petrel (*Procellaria westlandica*) (vulnerable);
- Sooty shearwater (*Puffinus griseus*) (near threatened); and
- Flesh-footed shearwater (*Puffinus carneipes*) (least concern).

This section provides a summary of the life histories of these species.

*Westland Petrel*

Westland petrels (*Procellaria westlandica*) are an endemic, highly pelagic species, ranging from Tasmania to the territorial waters of Chile (Biswell, 2007). Breeding for this species occurs between May and November in the coastal foothills near Punakaiki on the South Island's West Coast. Westland petrels (*Figure 4.50*) are often caught as by-catch in tuna fisheries in NZ and Australia (Biswell, 2007). They frequently follow trawlers and are at risk of being caught in trawl gear. This species is listed as Range Restricted by the DOC and of Least Concern by the IUCN Red List.

*Source: www.albatrossencounter.co.nz*

*Figure 4.50* *Westland Petrel*

*Sooty Shearwater*

The sooty shearwater (*Puffinus griseus*) (*Figure 4.51*) is one of the most widely distributed seabirds. This species breeds between November and May along the NZ coastline from Three Kings Island to the Campbell islands. This species also breeds in Australia, Chile and the Falkland Islands (Biswell 2007). These birds are often killed by trawl nets or warps used in the hoki, squid and scampi fisheries. This species is listed as under a Gradual Decline by the DOC and Near Threatened by the IUCN Red List.

*Source: http://www.nzbirdsonline.org.nz Flesh-Footed Shearwater*

*Figure 4.51* *Sooty Shearwater*

*Flesh-footed Shearwater*

Flesh-footed shearwaters (*Puffinus carneipes*) (*Figure 4.52*) are known to breed between December and May on 15 islands around the North Island and the Cook Strait (Biswell 2007). This species also breeds in Australia (Biswell 2007). These birds are often caught by longline fisheries and trawlers. This species is listed as under a Gradual Decline by the DOC and of Least Concern by the IUCN Red List.

*Source: http://www.nzbirdsonline.org.nz*

*Figure 4.52* *Flesh-footed Shearwater*

A large number of seabirds including albatrosses, petrels, shearwaters and boobies have foraging ranges which span across the South Pacific including the Project Area (MPI, 2013a). Many of these are included on the IUCN Red List of Threatened Species. The following three species are listed as either Endangered or Critically Endangered by the IUCN.

### *Chatham Albatross*

The critically endangered Chatham albatross is NZ's rarest endemic albatross and is distributed across the South Pacific Ocean west to Tasmania and east to South America. In winter the species migrates to the territorial waters of Chile and Peru. Chatham albatrosses have been caught in long-line fisheries and are reported in the by-catch of trawlers in NZ waters. This species only breeds on one large rock stack called The Pyramid in the Chatham Islands, around 630 km north-east of the Project Area. The breeding period runs from August-September to the following March-April. The diet of the Chatham albatross consists of fish and squid. Ground counts on The Pyramid between 1999-2003 revealed approximately 5,300 occupied sites (Robertson *et al.*, 2003 in Birdlife International, 2013) indicating a total breeding population of 5,300 pairs.

### *Northern Royal Albatross*

The northern royal albatross forages widely over the Tasman Sea for squid and fish, potentially in the vicinity of the Project Area. However, the species breeding sites are located far from this area (Chatham Islands, Auckland Island and Taiaroa Heads in the South Island). Egg-laying begins in late October and chicks depart the following year from August to October. Royal albatrosses usually live for up to 35 years and breeding occurs every two years. At sea, adults and fledglings have a high survival rate, indicating that fisheries related mortality is not a major threat to the species. The Chatham Islands population (99% of the total) is estimated at 6,500-7,000 pairs with approximately 5,200-5,800 pairs breeding each year. Around 25 pairs breed each year at Taiaroa Head (Robertson *et al.*, 2003 in Birdlife International, 2013).

### *Black Browed Albatross*

The black-browed albatross is common over shelves around NZ and Australia and is a recent colonizer in NZ. In the winter, birds from the Indian Ocean migrate to shelves off East Africa, Australia and NZ. This species feeds mostly on krill and fish, and occasionally squid, salps and jellyfish. Breeding occurs in low numbers on islands off the southern coast of NZ (Campbell, Antipodes and Snares Islands). Elsewhere, the species breeds on Cape Horn, Falkland, South Georgia, Crozet, Kerguelen, Heard and Macquarie islands. Breeding begins in August with eggs laid in late September and ends in April. Breeding occurs annually. Black browed albatross are often seen near trawlers and many fatalities are reported to occur each year due to trawl fisheries off South Africa and the Indian Ocean. In the southern hemisphere, the species are reported to be frequently captured in long-line fisheries. The total population of this species is estimated between one million and 2.5 million birds.

### 4.2.9 *Deep Sea Corals*

There are three main groups of corals that make up deep, cold-water coral communities being hard (stony) corals of the order Scleractinia, which form hard, ahermatypic reefs; black and horny corals of the order Antipatharia; and soft corals of the order Alcyonacea, which includes the gorgonians (sea fans). Different from the majority of shallower, warm-water corals, which require the symbiotic relationship with the photosynthesizing zooxanthellae for energy, cold-water corals rely on the capture and consumption of organic detritus and plankton that are transported by strong, often deep, sea currents (Friedman *et al.*, 2004). As they are not reliant on photosynthesis, cold-water corals can be found below the photic zone of ~200 m and into the deeper reaches of the ocean (Friedman *et al.*, 2004). Corals have been recorded at depths of up to 4954 m in the waters of NZ's EEZ (Consalvey *et al.*, 2006), however it is not known whether gorgonians are present in the Project Area.

According to the NABIS database (MPI, 2013, *Figure 4.53*), black corals are distributed off the east coast of the South Island, stretching along the Chatham Rise and as far south as Oamaru. They are also located around the east coast of the North Island, spanning west into the Cook Straight and south-east towards the Kaikoura peninsula, passing through the Project Area.

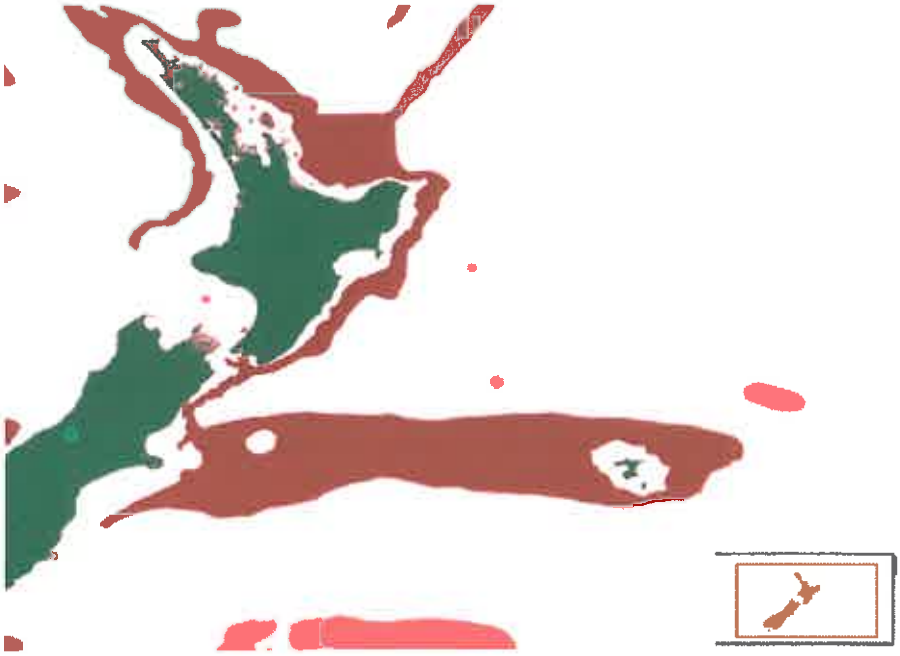


*Figure 4.53: Distribution of Black Coral in the Vicinity of the Pegasus Basin*

Black corals belong to the order Antipatharia, within the Anthozoa. About 58 black coral species have been identified in NZ waters, distributed between 29 and 50 degrees latitude. All species are protected under the Wildlife Act 1953. Although their depth and geographic distributions have not been analyzed in detail, most appear to live in the deep sea on seamounts or other available hard and stable substrate between 200 and 1000 m deep (i.e. the Chatham Rise).

Black corals are characterized by their erect and often bushy growth forms and hard proteinaceous skeleton that bears tiny polyps. Black corals are described as important structure forming corals, however despite their recognized ecological significance are understudied due to the inherent difficulties in observing them alive. Black corals have low mortality, growth rates, fecundity and recruitment. Colonies of black coral observed within the EEZ have been reported to reach 10 m in height and some specimens have been aged at over 300 years (Consalvey *et al.*, 2006).

A report on deep sea corals (NIWA 2002) indicate that red corals also occur within the Project Area. These corals are members of the order Anthoathecatae (hydrocorals or stylasterid corals) within Hydrozoa. The skeletons of these hydrocorals are much smaller and more fragile than stony corals. NZ has a very diverse range of hysrocorals, with around 40 species endemic to NZ (DOC, 2013). These corals, as well as black corals are protected under The Wildlife Act 1953.

### 4.2.10 *Protected Natural Areas in the Vicinity of the Project Area*

According to the World Database on Protected Areas, there are no Protected Natural Areas located within the Project Area, however, two Protected Areas occur along the neighboring coastline (south-east of the North Island) (UNEP and IUCN, 2009). These areas include the:

- Aorangi Forest Park; and
- Allsops Bay Wildlife reserve.

The Aorangi Forest Park is located around 25 km north of the Project Area. It features some of NZ's most striking landforms and provides habitat for a fur seal colony at Cape Palliser, the only colony in the North Island where breeding is well-established. This area also provides breeding habitat for the variable oystercatcher, banded dotterel and red-billed gull (DOC, 2013a). This park also contains Māori occupation sites – a kainga (a resting and eating place for travelers) and the Putangirua Pa site, on a steep outcrop (DOC, 2013a).

Allsops Bay Wildlife Reserve is an inland wetland area of Lake Wairarapa, thus not at risk of impacts from the Project.

*Marine Mammal Area of Ecological Importance (AEI)*

DOC has established AEI's for marine mammals based on information in the sightings, strandings and fisheries databases. This area surrounds the entire coast of NZ, extending south to the Auckland and Campbell islands, east along the Chatham Rise and north-east along the Kermadec Trench. The Project Area is located within an AEI. Under normal circumstances, marine seismic surveys would not be planned in these areas during key biological periods. Seismic survey operations within any AEI have more comprehensive planning requirements and considerations, including specific additional measures in the Marine Mammal Impact Assessment Process.

*Marine Mammal Sanctuaries*

Six gazetted Marine Mammal Sanctuaries (MMS) have been established throughout NZ fisheries waters to create a permanent refuge for marine mammals, and are included in the AEI. MMS are designed to protect marine mammals from harmful human impacts, particularly in vulnerable areas such as breeding grounds and on migratory routes (DOC, 2014).

No MMS have been identified within the Project Area (DOC, 2010a). The closest MMS's to the Project Area are the Clifford and Cloudy Bay MMS (over 15 km away) and the Bank Peninsula MMS (over 180 km away). The Clifford and Cloudy Bay MMS was established in 2008 to support the goals, management objectives and vision statement of the Hector's Dolphin Threat Management Plan (MPI, 2010). The specific MMS objectives are:

- *To protect key sites in New Zealand waters of significance to Hector's dolphins including the subspecies Maui's dolphin.*
- *To maintain or restore the distribution and abundance of Hector's dolphins, including the subspecies Maui's dolphin, in New Zealand waters.*
- *To achieve self sustaining populations of Hector's dolphins, including the subspecies Maui's dolphin, throughout their natural range.*
- *To significantly reduce or eliminate human related threats to Hector's and the subspecies Maui's Dolphin throughout their range.* (MPI, 2010)

The Clifford and Cloudy Bay MMS, established in 2008, covers approximately 142,716 hectares and extends over 338 km of coastline and is known to be an important area for Hector's dolphin. The MMS also forms part of the migratory route for humpback whales and southern right whales. Seismic activities are restricted within the boundaries of the sanctuary.

It is noted that in addition to the protection provided for Hector's dolphins by the Clifford and Cloudy Bay MMS and four other MMS, the areas that pose the greatest risk to the Hector's population are also covered by various fishing bans and restrictions. These areas include the eastern coast of the South Island. Combined, the areas covered by restrictions on set netting (the fishing method known to pose the greatest risk), have increased by more than 600 percent between 2003 and 2012. Almost 15,350 square kilometres of the coastal environment is closed to set net activity. Protective measures to avoid dolphin mortality from trawling activities have increased from 0 in 2003, to 6335 square kilometres in 2012. In 2012, after a Hector's or Maui's dolphin mortality resulting from set net activity was reported in an area outside of the closures implemented by MPI, a closure out to two nautical miles offshore was put in place (MPI, 2013r).

*Marine Reserves*

A total of 34 designated marine reserves exist along NZ's coast. These reserves are specified areas of the sea and foreshore that are managed for the preservation of their natural state as prime habitat for marine life. These areas are commonly utilized for scientific study. Marine reserves may be established in areas that contain underwater scenery, natural features, or marine life of such distinctive quality, or so typical, beautiful or unique that their continued preservation is in the national interest (DOC, no date).

Within these reserves, all marine life is protected, which includes the prohibition of fishing and the removal of both living and non-living marine resources. Dredging, dumping, building structures or discharges of any material is also prohibited (DOC, no date).

In November 2007, the government established 17 Benthic Protection Areas (BPAs) that close areas within NZ's EEZ to bottom trawling and dredging. These BPAs protect the biodiversity within approximately 1,100,000 $m^2$ of seabed – approximately 30% of the EEZ. There are two BPAs located on the mid and east Chatham Rise, to the south-east of the Project Area. There are no BPAs located inside the Project Area (MPI, 2009).

The Palliser Bay taiapure has been identified along the southern coastline of the North Island (MPI, 2013m). A taiapure is a fishing area which has customarily been of special significance to an iwi or hapū, as a source of food or for spiritual or cultural reasons.

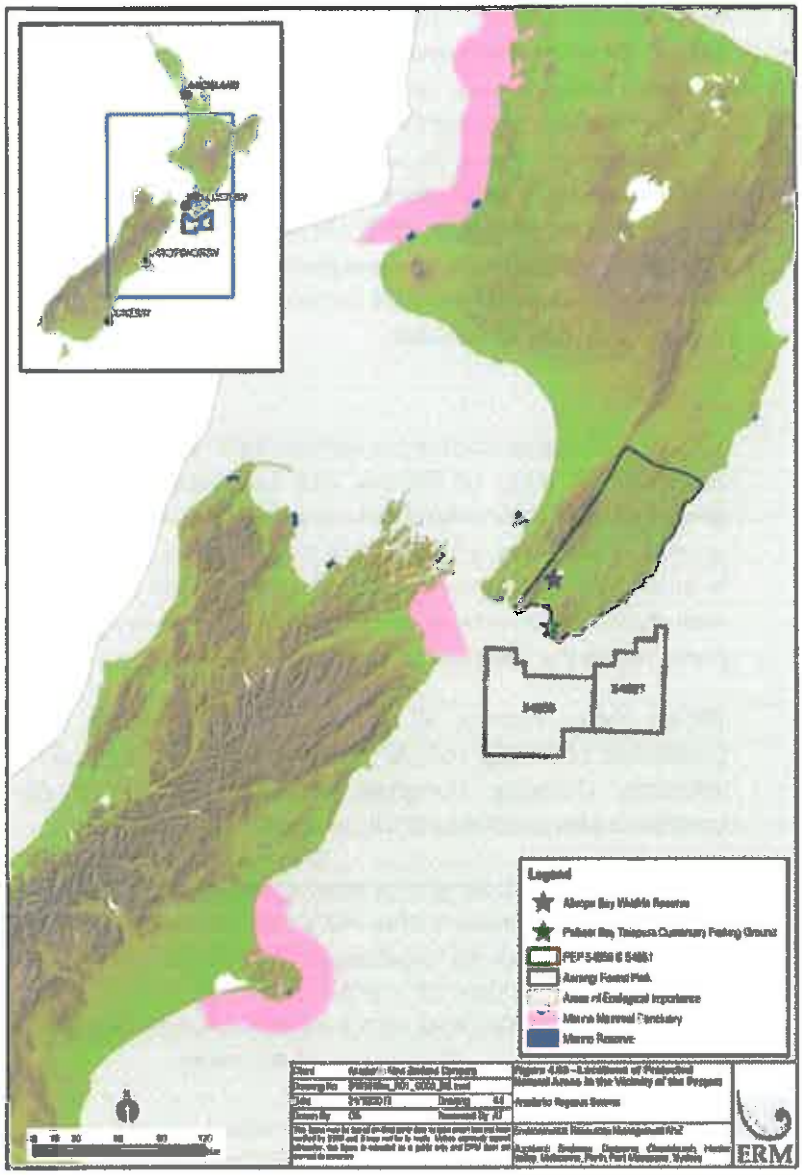



*Figure 4.54: Locations of Protected Natural Areas in the Vicinity of the Project Area*

## 4.3 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

This section describes the socio-economic and cultural aspects of the central eastern regions of NZ. The below sections provide an overview of the socio-economic and cultural conditions of the Wellington and Canterbury regions, which are the nearest regions of the country to the Project Area. An outline of the existing interests that could be affected by the survey and the consultation that has been undertaken with these parties is also provided.

## 4.4 OVERVIEW OF THE SOCIO-ECONOMIC ENVIRONMENT

### 4.4.1 General Demographics

The Wellington region is located at the southwest tip of the North Island and occupies an estimated land area of 8,140 km². The Canterbury region occupies an estimated land area of 45,238 km² and is NZ's largest region (Environment Canterbury, 2010). It is bound by the Pacific Ocean to the east, the Marlborough and Nelson regions to the north, the West Coast region to the west and the Otago region to the South.

#### *Population*

According to the 2006 census data, the population of NZ was 4,027,947, and had grown 8.4% since 2001. The Wellington region was the third largest NZ region by population, accounting for 448,956 persons, approximately 9% of the total national population. The Canterbury region was the second largest NZ region by population, accounting for 521,832 persons, approximately 13% of the total national population.

#### *Ethnic Composition*

The largest ethnic group in NZ in 2006 was the "NZ European" group, which accounted for approximately 2.6 million people, or 67.6% of the population. The next largest ethnic group nationwide was Māori, which accounted for approximately 565,000 people, or 14.6% of the population. The remainder of the population was comprised of people of Asian, Pacific, Middle Eastern, Latin American, African, or other origins. In 2006, NZ had a rather large and growing immigrant population: almost one quarter (22.9%) of people living in NZ in 2006 were born overseas, compared with 19.5% in 2001, and 17.5% in 1996 (Statistics NZ, 2006).

In 2006, people of NZ European descent accounted for 66.7% for the Wellington region's population and 77.4% of the Canterbury region's population. The 2006 census results also indicated that the next largest ethnic group in both regions was Māori, followed by Asians, Pacific peoples, then Middle Eastern/Latin American/African and people of other unspecified descent, which generally reflected the ethnic composition of the national population. 23.3% of the Wellington population were immigrants, having been born overseas compared with 17.9% of the Canterbury population and 22.9% for NZ as a whole.

*Income*

The median personal income for people aged 15 and over in NZ was NZ$24,400 in 2006. This figure was up 32% from NZ$18,500 in 2001 (Statistics NZ, 2006). Over that time, New Zealanders' purchasing power increased as well: the Consumer Price Index rose only 13% over the same period. The regions with the highest median annual personal incomes in 2006 were Wellington, Auckland, and Waikato, while the regions with the lowest median annual personal incomes were the West Coast, Gisborne, and Northland. Median annual personal incomes in the Wellington and Canterbury regions included NZ$28,000 and NZ$23,500 respectively. Important industries in the Wellington region's economy include: property and business services, government administration and defense. Important industries in the Canterbury region's economy include: wholesale and retail trade; manufacturing; property and business services; and health and community services. (Statistics NZ, 2007).

### 4.4.2 *Marine Traffic, Ports and Harbors*

NZ has thirteen major commercial ports and harbors. Three major commercial ports are adjacent to the Project Area: Lyttelton (Christchurch), Port Marlborough (Picton) and Wellington.

Lyttelton Port is the South Island's major deep-water port and is located approximately 200 km from the Project Area Lyttelton Port has four heavy duty concrete berths suitable for handling containerized cargo, multi-purpose vessels, roll-on/roll-off and conventional vessels as well as a further eight berths available for general cargo and an oil berth (Lyttelton Port of Christchurch, 2005).

Port Marlborough in Picton offers the deepest cargo berth in NZ and is the South Islands terminal port for inter-island passengers and freight ferries (PMNZ, 2011). This port is one of the busiest in NZ, with 4000 ship visits each year. A significant component of Port Marlborough is its facilities for tourism and leisure industry operators, where cruise ships transport more than a million passengers each year (PMNZ, 2011). This port is located approximately 110 km from the Project Area.

Centre Port in Wellington is NZ's most strategically situated intermodal hub, linking road, rail and domestic and international shipping services (CentrePort, 2013). Centre Port is utilized by approximately 4200 ships per year, with over 10.5 million tons of cargo handled by the port every year (CentrePort, 2013). This port also provides docking for a number of cruise operators and is located approximately 40 km from the Project Area.

There are no designated shipping lanes within the vicinity of the Project Area. As the majority of vessels accessing these east coast ports have origins or destinations either within NZ or further afield (e.g. Australia, Japan, Korea, Singapore), the most travelled routes are north or south along the coast within the 12 nm limit. Some local fishing vessels may pass through the Project Area.

There are no areas in the proximity of the Project Area that have been identified by Maritime NZ as precautionary areas to be avoided (Maritime NZ, unknown).

### 4.4.3 *Fishing*

Three primary types of fishing are practiced in NZ's coastal waters: commercial fishing; recreational fishing; and traditional or customary fishing as practiced by Māori. Commercial marine fisheries in NZ's Territorial Sea and EEZ are managed under the national QMS, which divides the area into several FMAs. Under the QMS, commercial fishers are assigned a catch limit designed to provide for continued sustainable harvest. Recreational fishers are not managed under a quota system, but are subject to catch limits and minimum sizes established by the government to prevent overexploitation of certain fish stocks. Under the terms of the *Fisheries Settlement Act 1992* and the *Māori Fisheries Act 2004*, Māori own a share of the commercial fish quota. Māori also may govern non-commercial customary fishing activities jointly with the NZ government, or independently within established mātaitai reserves (Statistics NZ, 2009). No data are currently available on customary fishing harvests.

Commercial fishing activities are the most intensely monitored fishing activities in NZ, and commercial fishers are the only sector of fishers for which accurate catch valuations exist (see *Section 4.2.3*). The total asset value of NZ's commercial fish resource for the year to September 2008 was estimated at NZ$3.97 billion (Statistics NZ, 2009), which represented a 45% increase over the twelve years since 1996. Twenty species contributed over 90% of the value of the national commercial fishery in 2007-8.

Recreational fishers are not currently required to report recreational catches of managed species, so tracking recreational harvest of marine fish in NZ is difficult. Sufficient information does not currently exist to value recreational fishery assets, but for some stocks recreational harvest accounts for a significant proportion of the total annual harvest (Statistics NZ, 2009). Due to the distance offshore, recreational and customary fishing are not expected to occur within the Project Area.

Further information on the fisheries and the recorded fisheries catch within the Project Area is included in *Section 4.2.3*.

*Employment Related to Fishing*

The exact number of professional fishers is not known because the government tracks agriculture, forestry, and fishing employment together as a single category. These industries together were however between the fifth- and eighth-largest employment categories in NZ from 2001 through 2007. Approximately twice as many men are employed in these industries as women. In the year ending March 2007, the Wellington region employed 880 people in agriculture, forestry or fishing (0.06% of the total number of people employed in that industry in NZ). The Canterbury regions employed the - fourth highest number of people in the agriculture, forestry and fishing sector behind the Waikato region, Taranaki/Manawatu-Wanganui regions and Otago/Southland(Statistics NZ, 2007), although the proportion of fishers within this category is not known.

### 4.4.4 *Oil and Gas Activity*

The Pegasus Basin has been very lightly explored. To date, no wells have been drilled in the region. Seismic surveys have been conducted within the region, notably the 1972 Gulf and Mobil surveys, a 1993 swath bathymetry survey, undertaken as part of the Geodynz Project, a collaboration between France and NZ, in which a 3,400 km 2D industry-standard survey acquired data across much of the basin (NZPAM, 2012). A multi-beam survey was undertaken in the Project Area by Anadarko in April 2013.

### 4.4.5 *Other Uses*

No specific information is available on other users of the ocean near or within the Project Area; however maritime shipping, recreational/tourism, and military vessels have the potential to traverse the Project Area during the MSS. There are no known shipwrecks or sites of heritage significance within the Project Area.

### 4.4.6 *Cultural Environment*

The 2006 census identified that Māori comprise 12.8% of the Wellington region population and 7.5% in the Canterbury population.

Māori have a close affinity with the natural environment in which they live, and have developed a complex spiritual, psychological and physical world view that focuses strongly on the management and custodianship of this environment. These interactions, and concepts of guardianship and authority such as kaitiaki and mana whenua, extend strongly into the coastal and marine environment as a result of the traditional history of Māori as seafaring island peoples. Māori have a long association with whales. While whales provided food and utensils, they also feature in tribal traditions and were sometimes guardians on the ancestors' canoe journeys to Aotearoa (Haami, 2012).

In recognition of the cultural importance placed on the coastal and marine environments by local iwi, and to ensure appropriate identification and management of the potential impacts of the Project activities, Anadarko has initiated an ongoing program of iwi engagement (see *Section 4.5.2* for further details and *Annex A* for the full list of consulted parties). Anadarko's iwi engagement activities have focused on building and maintaining open and effective relationships with iwi, providing iwi with information on the nature of the proposed MSS program and identifying concerns relating to the potential impacts of the activities such that management and mitigation measures can be developed to avoid or minimize these impacts.

*Tourism*

Coastal tourism in the Wellington region involves sailing, diving, kayaking, surfing, swimming and fishing. A number of businesses conduct tours of the area via boat or provide the hire of equipment such as kayaks, surfboards or boats. The F69 Shipwreck just off the coast of Wellington provides a unique diving experience. Tours and charters are also very popular with tourists and generally operate year round, including helicopter tours of the coast. A number of local bays, beaches and islands also provide attractions for tourists to explore.

Whale and dolphin watching is the primary marine based attraction within the Canterbury region, with the most popular area being Kaikoura. Over 800,000 tourists are reported to visit Kaikoura annually (Kaikoura Information and Tourism Inc., 2013). Whale watching is Kaikoura's most popular tourist attraction as the continental shelf is close to shore and upwellings in the area attract numerous bird species, whales and dolphins. Sperm whales (*Physeter macrocephalus*) are a major focus of this industry. A study conducted on this species recorded 2,111 sightings between 1998-2001 (Richter, Dawson & Slooten, 2003). Humpback whale, blue whale, Minke whale, pygmy sperm whale, southern right whale, beaked whale, dusky dolphin, Hector's dolphin, NZ fur seal and common dolphin are also regularly seen (these species are detailed above in *Section 4.2.6*). Killer whales are also regularly seen in Kaikoura, and southern right whale dolphins are occasionally seen (DOC, *pers. comm.*). Several operators at Kaikoura offer a wide range of marine mammal watching opportunities including boat based whale watching (one permit for Whale Watch Kaikoura Ltd) and aircraft based whale watching (fours permits) (DOC, 2012f). Whale Watch Kaikoura is an indigenous, 100% Maori owned and operated venture founded in 1987 to establish an economic base for the Ngai Tahu community. It has since grown into a multi-million dollar ecotourism business (Wearing and Cunningham, 2013).

Kaikoura also offers a number of other marine-based attractions ranging from dolphin and seal swimming to fishing, kayaking and diving.

## 4.5 CONSULTATION WITH EXISTING INTERESTS

Since December 2012 Anadarko have undertaken a comprehensive consultation program with stakeholders with both existing interests in the region of the Project, as well as Anadarko's NZ operations generally. The following sections outline the consultation relevant to this Project.

### 4.5.1 *Existing Interests*

Existing interests are defined in the *EEZ Act* as:

*"the interest a person has in –*

- *Any lawfully established existing activity, whether or not authorized by or under any Act or regulations, including rights of access, navigation and fishing;*
- *Any activity that may be undertaken under the authority of an existing marine consent granted under section 62;*
- *Any activity that may be undertaken under the authority of an existing resource consent granted under the Resource Management Act 1991;*
- *The settlement of a historical claim under the Treaty of Waitangi Act 1975;*

- *The settlement of a contemporary claim under the Treaty of Waitangi as provided for in an Act, including the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992;*

- *A protected customary right or customary marine title recognized under the Marine and Coastal Are (Takutai Moana) Act 2011."*

Those parties identified by Anadarko, with additional guidance by DOC, include:

- Iwi and hapu groups: Māori tribal groups that are generally associated with a recognized territory (or rohe);

- Local business interests;

- Local fishing interests;

- Local non-governmental organizations and environmental groups that have an expressed interest in the project.

- Maori electorate MPs:

  - Rino Tirakatene, MP for Te Tai Tonga

  - Meka Whaitiri, MP for Ikaroa-Raawhiti

- Environmental Groups:

  - Forest and Bird

  - WWF New Zealand

### 4.5.2 *Consultation*

Anadarko selected a dual approach in their consultation with both in person meetings, including hui and phone calls, as well as written notification of the Project accompanied by a factsheet on the Project itself.

#### *Iwi Consultation*

Consultation with iwi identified as having a potential interest in the Pegasus Basin began as soon as the announcement was made on 12th December 2012, awarding two exploration blocks in the basin to Anadarko. This took the form of letters to each iwi introducing the company, and offering to meet for further discussions if that was wanted (*Table 4.7*).

Meetings were subsequently held with representatives from Ngati Toa and the Port Nicholson Settlement Trust at which no particular issues in relation to seismic testing were raised.

Of key importance however was the Kaikoura-based Ngati Kuri runaka of Ngai Tahu. Former Energy Minister, Hon Phil Heatley, had offered to bring the successful bidder for the Pegasus blocks to an introductory hui at Takahanga Marae in Kaikoura. This took place on 8th February 2013 in the presence of Hon Simon Bridges, who had replaced Mr Heatley as Energy Minister in the interim. It was disclosed at this meeting that Anadarko proposed to carry out 2D seismic testing towards the end of the year in accordance with the conditions of its exploration license. No issue was raised in relation to seismic testing on this occasion, but in a subsequent meeting with tourism industry interests in Kaikoura, a representative from Whale Watch Kaikoura expressed concern that when seismic surveying had taken place in the area on a previous occasion, whales had been absent from the coastline for a number of weeks afterwards.

It was acknowledged that there was no compelling scientific evidence either way in relation to the impact of seismic testing on large marine mammals, but nevertheless the concern remained. It was agreed that to help increase knowledge on this issue, Anadarko would share information with Whale Watch Kaikoura in the form of daily marine mammal observations carried out aboard the seismic vessel. This arrangement was confirmed in subsequent e-mail correspondence.

In a separate meeting, an offer was made to Ngati Kuri representatives to have a runaka member visit the seismic vessel when it arrived in Wellington to help build understanding among the iwi of what was involved in seismic testing, and the steps that are taken to avoid impacts on marine mammals. A runaka meeting on 10th November 2013 confirmed interest in this offer, and a representative has offered to come to Wellington look over the vessel if the timing is convenient.

There has also been occasional e-mail correspondence between Anadarko and runaka members sharing information on overseas research into seismic testing impacts on marine mammals, and this exchange is ongoing. A formal letter outlining key concerns from Ngati Kuri, including those outlined above, was received on 13th December 2013 and is provided within *Annex A*.

In response to this letter and to address the concerns raised by Ngati Kuri, Anadarko has added the following items to the Marine Mammal Mitigation Plan (refer to *Section 9* for further detail):

- Anadarko will provide a copy of this MMIA to Ngati Kuri, once accepted by DOC;
- Anadarko will be conducting the survey in January 2013, which does not coincide with a period of known whale migration or calving. Whale migration is known to occur along the east coast of the South Island in winter;
- Anadarko will ensure that communication is possible between the vessel and Whale Watch Kaikoura at all times during the MSS program;

- Anadarko will provide copies of the monitoring reports completed by the MMOs to Ngati Kuri, at completion of the MSS;
- Anadarko will consider covering the cost of necropsies for marine mammals that strand in the area of the survey on a case by case basis in consultation with DOC;
- The data collected during this survey will be utilized to enhance mitigation measures in future surveys in the Pegasus Basin; and
- Anadarko will ensure that there is ongoing communication with Ngati Kuri in terms of timing and content around planned activities.

*Table 4.7* below outlines the iwi consultation relating to the Project that has been undertaken by Anadarko.

*Table 4.7: An Overview of Consultation Undertaken by Anadarko, with Iwi*

| Organization Consulted | Individual Consulted | Date and method of engagement | Feedback received |
|---|---|---|---|
| Rangitane O Wairarapa Inc | Jason Kerehi | 12th December 2012 Letter | No issue raised |
| Ngati Kahungunu Iwi Inc | Ngahiwi Tomoana | 12th December 2012 Letter | No issue raised |
| Te Runanga a Rangitane o Wairau Trust | Judith MacDonald | 12th December 2012 Letter | No issue raised |
| Te Atiawa ki te Upoko o te Ika a Māui Pōtiki Trust | John Atiawa Warren | 12th December 2012 Letter | No issue raised |
| Ngati Toa Rangatira | Taku Parai | 12th December 2012 Letter | No issue raised |
| Ngati Kuia | Waihaere (Joe) Mason | 12th December 2012 Letter | No issue raised |
| Ngati Koata Trust | Jeanette Grace | 12th December 2012 Letter | No issue raised |
| Ngai Tahu/Ngati Kuri | Sir Mark Solomon | 12th December 2012 Letter and Phone call | Meeting at marae previously arranged |
| Ngai Tahu | Takahanga Marae | 8th February 2013 Introductory hui | Concerned with the potential for a spill in customary food gathering area, recreation and tourism |
| Ngati Toa (Wellington Office) | Matiu Rei | 12th February 2013 Face to face meeting | No issue raised but agreed to maintain contact |
| Port Nicholson Block Trust (at Trust offices, Wharewaka, Wellington waterfront) | Liz Mellish, Morrie Love, Mahara Okeroa | 8th March and 6th May 2013 Face to face meeting | Concerned with impact of exploration on fishing interests |
| Ngai Tahu/Ngati Kuri | Takahanga Marae | 17th September 2013 Hui | Concerned with the potential for a spill in customary food gathering area |

*Other Existing Interests*

On 9th December 2013, Anadarko distributed a letter of notification to those that had been identified as having an existing interest that may be impacted by the Project, as well as others. A copy of the letter distributed can be found in *Annex A* of this MMIA and a list of recipients can be found in the below *Table 4.8*. Within the letter, contact details were provided to recipients, should they wish to contact Anadarko with any concerns or questions. At the time of this MMIA being written, no formal responses to the notification letter have been received, written or otherwise.

*Table 4.8: A List of Those with Existing Interests that Received a Notification Letter*

| Full Name | Position | Organization |
|---|---|---|
| Grant Robertson | MP for Wellington Central | |
| Colin King | MP for Kaikoura | |
| John Hayes | MP for Wairarapa | |
| Trevor Mallard | MP for Hutt South | |
| Celia Wade-Brown | Mayor of Wellington | |
| Ray Wallace | Mayor of Hutt City | |
| Fran Wilde | Chair | Greater Wellington Regional Council |
| Adrienne Staples | Mayor of South Wairarapa | |
| Alistair Sowman | Marlborough Mayor | |
| Winston Gray | Kaikoura Mayor | |
| Jason Kerehi | Chief Executive | Rangitane o Wairarapa Incorporated |
| Ngahiwi Tomoana | Chairman | Ngati Kahungunu Iwi Incorporated |
| Judith MacDonald | Chair | Te Runanga a Rangitane o Wairau Trust |
| John Atiawa Warren | Chairman | Te Atiawa ki te Upoko o te Ika a Māui Pōtiki Trust |
| Taku Parai | Chair | Ngati Toa Rangatira |
| Waihaere (Joe) Mason | Chair | Ngati Kuia |
| Jeanette Grace | | Ngati Koata Trust |
| Matiu Rei | Executive Director | Te Runanga o Toa Rangatira Inc |
| Mahara Okeroa | | Port Nicholson Block |
| Liz Mellish | Natural Resources Advisor | Port Nicholson Block |
| Sir Mark Solomon | | Te Runanga o Ngai Tahu |
| Gina Solomon | Spokeswoman | Te Korowai |

In addition to the existing interests outlined above on 18th November 2013 both Forest and Bird (Kaikoura, Wellington, Marlborough and Wairarapa) and World Wildlife Fund NZ, were provided with a letter accompanied with a Seismic Survey factsheet, as shown in *Annex A* of this MMIA. Also, on 31st July 2013, Anadarko met with Whale Watch Kaikoura (Kauahi Ngapora) and Dolphin Encounter (Dennis and Lynette Buurman) to discuss the seismic survey program.

*Summary of Findings*

Through the extensive consultation undertaken by Anadarko a series of concerns were identified relating to the impacts the Project may have on existing interests. These concerns included the potential risk of an oil spill occurring and this impacting on their interests including kai moana, fisheries, recreation and tourism. This MMIA addresses this risk in *Section 6.3*. In addition to the risk of spills, the impacts seismic activities may have on Whale Watch Kaikoura's operations were raised. Such impacts relate directly to the impacts of seismic activities on marine mammals, which are addressed in *Section 6.2* of this MMIA.

Additional commitments made by Anadarko to address the concerns raised include the provision of daily marine mammal observations carried out aboard the seismic vessel to Whale Watch Kaikoura and an offer has been made to Ngati Kuri representatives to have a runaka member visit the seismic vessel when it arrived in Wellington to help build understanding among the iwi of what was involved in seismic testing, and the steps that are taken to avoid impacts on marine mammals.

# 5 ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

This chapter presents the methodology used to undertake the environmental impact assessment of Anadarko's proposed MSS activities within the Project Area. *Section 6* documents the likely environmental impacts of the routine aspects of the Project as well as potential accidental events. *Section 7* provides a summary of the potential impacts associated with each aspect of the Project.

## 5.1 METHODOLOGY

This section describes the methodology adopted for identifying and assessing impacts of the MSS activities on the physical, biological and human environment. There are four stages to the impact assessment process, which are described in the sections that follow.

### 5.1.1 *Assessment Methodology Stage I: Identification of Potential Impacts and Scoping*

Environmental impacts arise as a result of Project activities either interacting with environmental receptors directly or causing changes to the existing environment such that an indirect effect occurs. Impacts may be described and quantified in a number of ways. The types of impacts that may arise from Project activities and the terms used in this assessment are shown in *Box 5.1*.

The impacts that result from routine steady-state activities are assessed, as are those that could result from credible accidental or other unplanned events within the Project scope (for example a fuel spill or blow-out) or due to external events (for example severe storm conditions) that could affect the Project. The impacts of non-routine events are assessed in terms of associated risk, by taking into account both the consequence of the event and the probability of its occurrence.

At this stage, identification of potential impacts is carried out prior to detailed assessment of the relative importance of each issue, the sensitivity of baseline resources or the magnitude of the potential impact, and does not take account of potential mitigation measures.

Certain issues are scoped out because their impact on the environment is judged to be so small as to be irrelevant. These issues are not considered further in the assessment process. Any impact which is considered to be of likely significance is carried forward to the next stage of the impact assessment process. Refer to *Table 6.1* for a list of issues which have been scoped out of this EIA.

*Box 5.1: Types of Impact*

**1. Nature of Impact**

- *Negative* – an impact that is considered to represent an adverse change from the baseline, or to introduce a new undesirable factor.
- *Positive* – an impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.

**2. Type of Impact**

- *Direct (or primary)* – impacts that result from a direct interaction between a planned Project activity and the receiving environment.
- *Secondary* – impacts that follow on from the primary interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g. where the loss of part of a habitat affects the viability of a species population over a wider area).
- *Indirect* – impacts that result from other activities that are encouraged to happen as a consequence of the Project (e.g. in-migration for employment placing a demand on natural resources).
- *Cumulative* – impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

**3. Duration of Impact**

- *Temporary*: impacts are predicted to be of short duration and intermittent/occasional in nature.
- *Short-term*: impacts that are predicted to last only for a limited period (e.g. during a MSS) but will cease on completion of the activity, or as a result of mitigation/reinstatement measures and natural recovery.
- *Long-term*: impacts that will continue over an extended period, but cease when the Project stops operating. These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended time period (e.g. repeated seasonal disturbance of species as a result of maintenance/inspection activities).
- *Permanent*: impacts that occur during the development of the Project and cause a permanent change in the affected receptor or resource that endures substantially beyond the Project lifetime.

**4. Scale of Impact**

- *Local*: impacts that affect locally important environmental resources or are restricted to a single habitat/biotope, a single (local) administrative area, a single community.
- *Regional*: impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem.
- *National*: impacts that affect nationally important environmental resources, affect an area that is nationally important/protected or have macro-economic consequences.
- *International*: impacts that affect internationally important resources such as areas protected by International Conventions.
- *Trans-boundary*: impacts that are experienced in one country as a result of activities in another.

### 5.1.2 *Assessment Methodology Stage II: Developing Mitigation Measures*

A key component of the EIA process is to explore practical ways of avoiding or reducing potentially significant impacts of the proposed project activity. These are commonly referred to as mitigation measures and have been incorporated into the proposed Project as commitments by Anadarko. Mitigation is aimed at preventing, minimizing or managing significant negative impacts to as low as reasonably practicable (**ALARP**) [2], and optimizing and maximizing any potential benefits of the Project.

The approach taken to identifying and incorporating mitigation measures into the Project is based on a typical hierarchy of decisions and measures, as described in *Box 5.2*. This is aimed at ensuring that wherever possible potential impacts are mitigated at source rather than mitigated through restoration after the impact has occurred. Thus, the majority of mitigation measures fall within the upper two tiers of the mitigation hierarchy and are effectively built into the planned Project implementation.

*Box 5.2:* *Typical Mitigation Hierarchy*

THE MITIGATION HIERARCHY FOR PLANNED PROJECT ACTIVITIES

*Avoid at Source; Reduce at Source*

**Avoiding or reducing at source is essentially 'designing' the Project so that a feature causing an impact is designed out (e.g. a waste stream is eliminated) or altered (e.g. reduced waste volume) - often called minimization.**

*Abate on Site*

**This involves adding something to the basic design or procedures to abate the impact - often called 'end-of-pipe'. Pollution controls fall within this category.**

*Abate Offsite/at Receptor*

**If an impact cannot be abated on-site then measures can be implemented off-site. An example of this in the case of the MSS program would be disposing of waste generated on board at a proper waste facility onshore. Measures may also be taken to protect the receptor.**

*Repair or Remedy*

**Some impacts involve unavoidable damage to a resource, e.g. land disturbance or shoreline pollution arising from an oil spill. Repair essentially involves restoration and reinstatement type measures, such as base camp closure or, in the case of an oil spill that has beached, clean-up of the shoreline.**

[2] As Low As Reasonably Practicable (ALARP) is the point at which the cost and effort (time and trouble) of further risk reduction is grossly disproportionate to the risk reduction achieved.

### 5.1.3 *Assessment Methodology Stage III: Evaluating Residual Impacts*

Following the identification of potential environmental impacts (Stage I), their significance is assessed, taking into account those proposed mitigation measures already incorporated into the design of the Project and any further mitigation measures that are considered feasible and justified (Stage II). Mitigation measures are applied to reduce impacts to ALARP, meaning that impacts may not be eliminated entirely. These remaining impacts are termed residual impacts.

One objective of the EIA is to understand the significance of the residual impacts that will remain, after mitigation measures have been designed into the intended activity, and whether some form of monitoring or measurement might therefore be justified.

For the purposes of this EIA, the following definition of significance has been adopted:

> *An impact is significant if, in isolation or in combination with other impacts, it should in the judgment of the EIA team be taken into account in the decision-making process, including the identification of mitigation measures and potential consenting conditions.*

In assessing whether an impact is significant, reference has been made to evaluation criteria adopted for the Project. The below tables outline the criteria applied to determine each component of this process including magnitude (*Table 5.1*) and sensitivity (*Table 5.2*). Legal standards and policy guidance (outlined in *Section 2*), literature reviews and accepted best practice have also been considered.

Criteria for assessing the significance of impacts stem from the following key elements.

- The magnitude (including nature, scale and duration, as defined in *Box 5.1* above) of the change to the natural environment (for example, loss or damage to habitats or an increase in noise), which has been expressed in quantitative terms wherever practicable (refer to *Table 5.1*).

- The nature of the impact receptor, which may be physical, biological, or human (refer to *Table 5.2*). Where the receptor is physical (e.g. a water body) its quality, sensitivity to change and importance have been considered. Where the receptor is biological, its importance (for example its local, regional, national or international importance) and its sensitivity to the impact have been considered. For a human receptor, the sensitivity of the community or wider societal group has been considered along with its ability to adapt to and manage the effects of the impact.

- The likelihood (probability) that the identified impact will occur has been estimated based upon experience and/or evidence that such an outcome has previously occurred.

The significance of impacts has then been defined, based on the sensitivity of the receptor and the magnitude of impact. This overall significance is represented for each impact through a matrix of magnitude vs. sensitivity/value as shown in *Table 5.3*.

The residual impacts have been described in terms of their significance and the nature of the impact is qualified on the basis of the descriptors in *Box 5.1* (e.g. short-term, localized etc.). The criteria used to determine the significance of a residual impact used either:

- Accepted numerical limits and standards; or
- A combination of the magnitude of change caused by the Project and the value/sensitivity of the receptor/resource that is impacted.

*Table 5.1: The Criteria for Assessing the Magnitude of Impacts on the Seabed, Seawater Quality, Ecological and Social Receptors*

| | Seabed Disturbance | Seawater Quality[1] | Ecology | Social |
|---|---|---|---|---|
| **Negligible** | Immeasurable, undetectable or within the range of normal natural variation | Immeasurable, undetectable or within the range of normal natural variation | Immeasurable, undetectable or within the range of normal natural variation | Change remains within the range commonly experienced within the household or community |
| **Small** | Minimal seabed disturbance | Slight change in water quality expected over a limited area with water quality returning to background levels within a few meters; and / or<br>Discharges are well within benchmark effluent discharge limits | Affects a specific group of localized individuals within a population over a short time period (one generation or less), but does not affect other trophic levels or the population itself. | Perceptible difference from baseline conditions. Tendency is that impact is local, rare and affects a small proportion of receptors and is of a short duration |
| **Medium** | Localized and/or short term disturbance of seabed | Temporary or localized change in water quality with water quality returning to background levels thereafter; and / or<br>Occasional exceedance of benchmark effluent discharge limits | Affects a portion of a population and may bring about a change in abundance and/ or distribution over one or more generations, but does not threaten the integrity of that population or any population dependent on it. | Clearly evident difference from baseline conditions. Tendency is that impact affects a substantial area or number of people and/or is of medium duration. Frequency may be occasional and impact may potentially be regional in scale |
| **Large** | Widespread and/or long term disturbance or permanent change to the seabed | Change in water quality over a large area that lasts over the course of several months with quality likely to cause secondary impacts on marine ecology; and / or<br>Routine exceedance of benchmark effluent discharge limits | Affects an entire population or species in sufficient magnitude to cause a decline in abundance and/ or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return that population or species, or any population or species dependent upon it, to its former level within several generations. | Change dominates over baseline conditions. Affects the majority of the area or population in the area of influence and/or persists over many years. The impact may be experienced over a regional or national area |
| **Positive** | In the case of positive impacts, it is generally recommended that no magnitude be assigned, unless there is ample data to support a more robust characterization. It is usually sufficient to indicate that the Project will result in a positive impact, without characterizing the exact degree of positive change likely to occur | | | |

*Notes: [1] Seawater Quality criteria are also applied to Air Quality impacts*

*Table 5.2: The Criteria for Assessing the Sensitivity of the Seabed, Seawater Quality, Ecological and Social Resources and/or Receptors*

| | Seabed Disturbance | Seawater Quality[1] | Ecology | Social |
|---|---|---|---|---|
| **Low** | Existing seabed quality is good and the ecological resources that it supports are not sensitive to disturbance | Existing water quality is good and the ecological resources that it supports are not sensitive to a change in water quality | Ecological receptors are abundant, common or widely distributed and are generally adaptable to changing environments. Species are not endangered or protected. | Minimal areas of vulnerabilities; consequently with a high ability to adapt to changes brought by the Project.<br>Any positive impacts will result in benefits, but only at a minor level. |
| **Medium** | Existing seabed quality shows some signs of stress and/ or supports ecological resources that could be sensitive to change in quality or physical disturbance (secondary ecological impacts are possible). | Existing water quality already shows some signs of stress and/ or supports ecological resources that could be sensitive to change in water quality | Some ecological receptors have low abundance, restricted ranges, are currently under pressure or are slow to adapt to changing environments. Species are valued locally / regionally and may be endemic, endangered or protected. | Some, but few areas of vulnerabilities; but still retaining an ability to at least in part adapt to change brought by the Project<br>Any positive impacts will result in benefits at a moderate level. |
| **High** | Seabed quality is already under stress and/ or the ecological resources it supports are very sensitive to change (secondary ecological impacts are likely) | Existing water quality is already under stress and/ or the ecological resources it supports are very sensitive to change (secondary ecological or health impacts are likely) | Some ecological receptors in the area are rare or endemic, under significant pressure and / or highly sensitive to changing environments. Species are valued nationally /globally and are listed as endangered or protected. | Profound, or multiple levels of vulnerabilities that undermine the ability to adapt to changes brought by the Project<br>Any positive impacts will result in major benefits. |

*Notes:* [1] *Seawater Quality criteria are also applied to Air Quality impacts*

*Table 5.3: Overall Significance Criteria for Impacts in the EIA*

| | | *Sensitivity/Value of Receptor* | | |
|---|---|---|---|---|
| | | **Low** | **Medium** | **High** |
| ***Magnitude of Impact*** | **Negligible** | Negligible | Negligible | Negligible |
| | **Small** | Negligible | Minor | Moderate |
| | **Medium** | Minor | Moderate | Major |
| | **Large** | Moderate | Major | Major |
| | **Positive** | Minor | Moderate | Major |

For this assessment, four impact significance categories have been applied:

- Negligible;
- Minor significance;
- Moderate significance; and
- Major significance.

The definitions of the above impact significance categories are defined in *Box 5.3*. Impacts of major significance are deemed intolerable and changes to the Project design, mitigation and control measures must be applied to reduce impacts to an acceptable level (no more than minor) before the Project can proceed.

*Box 5.3: Categories of Impact Significance*

- Negligible is where a resource, receptor, or community will not be affected by a particular activity or the predicted effect is deemed to be 'imperceptible'.
- An impact of minor significance (a 'minor impact') is one where an effect will be experienced, but the impact magnitude is sufficiently small (with or without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value. An inconvenience may be caused, but with little or no consequence to long-term livelihoods, culture, quality of life, or resources.
- An impact of moderate significance (a 'moderate impact') will be within accepted limits and standards. Moderate significance also applies where livelihoods, culture, quality of life, or resources are noticeably impacted, affecting a small number of households, and where those affected will be able to adapt to the new conditions.
- An impact of major significance (a 'major impact') is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. Major significance also applies where there are widespread, severe, and irreversible consequences for livelihoods, culture, quality of life or resources and where those affected will be unable to adapt to the new conditions.

### 5.1.4 *Assessment Methodology Stage IV: Re-evaluating Significant Residual Impacts*

For residual impacts assessed to be of moderate or greater significance, additional mitigation measures are proposed to further reduce their significance. This process is iterative and is repeated until residual impacts are ALARP.

### 5.1.5 *Evaluation Criteria for Accidental or Unplanned Events*

The approach adopted in this assessment considers the likelihood of an unplanned event occurring, and its likely consequence on the environment and public health and safety if it does occur. A qualitative approach to impact prediction has been adopted. Criteria to assess the impacts from accidental events are presented below in *Table 5.4* and *Table 5.5*, with the overall unplanned event impact significance criteria presented in *Table 5.6*.

*Table 5.4: Likelihood Categories for Unplanned Events*

| Likelihood | Definition |
|---|---|
| Extremely Unlikely | The event is extremely unlikely to occur under normal operating conditions but may occur in exceptional circumstances |
| Unlikely | The event is unlikely but may occur at some time during normal operating conditions |
| Possible | The event is likely to occur at some time during normal operating conditions |
| Likely | The event will occur during normal operating conditions (is inevitable) |

*Table 5.5: Severity Criteria for Unplanned Events*

| Severity | Definition |
|---|---|
| Low | • Some damage to the environment/ very localized<br>• No sensitive resources impacted<br>• Rapid degradation of spilled materials and rapid recovery of affected resources |
| Medium | • Localized environmental damage<br>• No sensitive resources impacted<br>• Degradation of spilled materials and full recovery of affected resources |
| High | • Severe environmental damage<br>• Sensitive resources impacted<br>• Recovery of affected resources is very slow |

*Table 5.6: Unplanned Event Impact Significance Criteria*

| | | *Severity of Impact* | | |
|---|---|---|---|---|
| | | **Low** | **Medium** | **High** |
| ***Likelihood*** | **Extremely Unlikely** | ALARP | ALARP | ALARP |
| | **Unlikely** | ALARP | Minor | Moderate |
| | **Possible** | Minor | Moderate | Major |
| | **Likely** | Moderate | Major | Major |

### 5.1.6 *Assessment Methodology Stage IV: Re-evaluating Significant Residual Impacts*

At this stage, for residual impacts assessed to be of moderate or greater significance, additional mitigation measures are proposed to further reduce their significance. This process is iterative and is repeated until residual impacts are insignificant, or until the need for compensation is identified.

### 5.1.7 *Dealing with Uncertainty in the Assessment of Impacts*

EIA is a process that deals with the future, and there is inevitable uncertainty that arises between the predictions made and what will actually happen during the course of the Project. However, the MSS process is widely practiced, the sources of impacts are well-understood and the areas of interaction with the receiving environment have been well-characterized by past projects. Anadarko's proposed program is comparable to many previous MSS programs conducted around the globe so inferences can be made through prior experience.

Impact predictions have been made using available data, but where significant uncertainty remains, this is acknowledged and an indication of its scale is provided. Where the sensitivity of a resource to any particular activity is unknown and the magnitude of impacts cannot be predicted, the EIA team has used its professional experience to judge whether a significant impact is likely to occur or not.

# 6 SOURCES OF IMPACTS FOR MARINE SEISMIC SURVEY (MSS)

Sources of environmental impacts may include routine operations that occur as part of standard MSS procedure, or non-routine events or incidents. This assessment considers how the various components of routine operations and non-routine events could affect aspects of the physical, biological and human environment within the project area.

## 6.1 IMPACT ASSESSMENT SCOPE

This impact assessment considers the impacts of Anadarko's MSS program on relevant environmental resources and receptors. It addresses all impacts that will occur and may occur during the Project.

As discussed in *Section 5.1.1*, a number of impacts have been scoped out of the Project because their impact on the environment is judged to be so small as to be irrelevant. This EIA has scoped the focus of the Impact Assessment down to those impacts that are considered to be of likely significance.

Those resources/receptors with interactions that have been identified as possible, but that are not likely to lead to impacts of significance are presented in *Table 6.1*.

*Table 6.1: Interactions with Resources/Receptors Identified as Possible, but Considered to be of Unlikely Significance*

| Project Activity and Resource/Receptor | Justification for Expectation of Insignificant Impact |
|---|---|
| Seawater Quality | Although deployed into the sea, there will be no discharges released directly from the MSS operating equipment. Potential impacts to seawater from MSS activities are therefore considered to be negligible. |
| Marine vessels | Given the limited duration of the MSS activity, limited number of vessels and area used by the MSS vessels, it is unlikely that the Project would result in any form of navigational interference with other vessels. |
| Marine reptiles | Marine reptiles are characteristically found in warm temperate seas, (WWF, 2010g) and although sightings of leatherback and green turtles have been recorded on Banks Peninsula (DOC, 2010a), it is considered unlikely that marine reptiles would be encountered in the Project Area. In addition, considering that the seismic vessel and support vessels will be in transit during the MSS program, it is unlikely that they will present a source of attraction for marine reptiles. As such, they are unlikely to be subject to any impacts of significance. |
| Marine mammals, and seabirds | Discharges of liquid waste from vessels may interact with marine mammals, marine and seabirds if they are present within the mixing zone at the time of discharge. However, given the unlikely nature of such an occurrence eventuating, coupled with the short duration of exposure should it occur, it is unlikely that any impacts will be significant. |

| Project Activity and Resource/Receptor | Justification for Expectation of Insignificant Impact |
|---|---|
| Public health and safety | During MSS activities, the seismic and support vessels may navigate waters used by other commercial and recreational seafarers and as such there is a risk to the health and safety of the public. However interaction is considered to be minimal, given the limited number of vessels involved and the limited duration of the Project. Furthermore, given the stringent regulations of maritime navigation in NZ it is likely that should any impacts to Public Health and Safety occur, they will be insignificant.<br>In the event that anything or anyone approaches the seismic survey vessel, the Crown Minerals Act provides for a 500m non-interference zone around the drilling vessel into which unauthorized entry is prohibited. For the duration of the drilling and proposed VSP activity, Anadarko will maintain good lines of communication with enforcement authorities and will seek their assistance should anybody break the law and endanger themselves by intruding into the 500m zone. |

Apart from the seismic equipment (i.e. airguns) and data gathering and processing equipment (i.e. hydrophones), seismic vessels are specialized ships equipped and operated as any vessel of similar dimensions.

Interactions from MSS activities that have the potential to lead to significant impacts are presented in *Table 6.2* and will be the focus of this impact assessment.

*Table 6.2: Environmental Impacts from Project Activities Considered to be of Likely Significance*

| Activity | Potential Environmental Impact |
|---|---|
| Routine Activities | |
| Physical presence of the survey vessel, streamer and chase vessels (*Section 6.2.1*) | Interference with local fishing activities and potential damage to fishing equipment<br>Interaction or interference with marine traffic<br>Indirect effects on fisheries<br>Change in marine bird behavior<br>Interaction or interference with marine mammals |
| Source sound emissions (*Section 6.2.2*) | Physiological effects on marine fauna from exposure noise or associated pressure effects<br>Behavioral disturbance leading to behavioral changes or displacement<br>Interference with the use of acoustic communication signals, or naturally-produced cues used by marine animals<br>Disruption to feeding, spawning and calving activities of marine fauna |
| Solid and liquid wastes generated on the vessels (*Section 6.2.3*) | Sanitary and domestic wastewater<br>Discharge of bilge and drainage waters |
| Atmospheric emissions (*Section 6.2.4*) | Estimated fuel consumption<br>Total air emission estimates for the Project Area MSS |

| Activity | Potential Environmental Impact |
|---|---|
| *Non-Routine Activities* | |
| Introduction of invasive marine species (*Section 6.3.1*) | |
| Streamer cable break and cable release (*Section 6.3.2*) | |
| Fuel/oil spill from vessels (*Section 6.3.3*) | |
| Vessel collision or sinking (*Section 6.3.4*) | |
| Impacts of natural disasters (*Section 6.3.5*) | |

## 6.2 ASSESSMENT OF IMPACTS FROM ROUTINE ACTIVITIES

### 6.2.1 *Physical Presence of the Survey Vessel, Streamers, and Support Vessels*

Three vessels have been engaged by Anadarko to conduct the MSS program – the seismic survey vessel, *MV Duke*, and two support vessels.

MSS have the potential to interfere with the activities and the local social environment of other sea users or environmental receptors through the following specific mechanisms, specifically associated with the physical presence of the seismic vessels and equipment:

- Interference with local fishing activities and potential damage to fishing equipment;
- Interaction or interference with marine traffic;
- Indirect effects, such as temporary changes in the abundance or behavior of fish species targeted by established fisheries;
- Temporary change in marine bird behavior; and
- Interaction or interference with marine mammals.

*Interference with Local Fishing Activity and Damage to Fishing Equipment*

The presence of seismic vessels could result in disturbance of offshore fishing activities and the exclusion of fishing vessels from survey areas. If fishing vessels are unaware that the survey vessel is operating, they may cross the streamers and cause damage to either vessel or fishing and survey equipment. Streamers can also become tangled in set nets should they be present in the area, causing damage.

As discussed in *Section 4.2.3*, The Project Area is located across three MPI fisheries regions (FMA 2, 3 and 4) however, only covers a small proportion of the total 1,090,000 km² FMA available for fishing operations. The magnitude of such an impact on local fishing activities is therefore considered to be ***small***, given that impacts are local, temporary in nature (approximately 42 days) and will affect only a small proportion of the local fishing industry. The sensitivity of the local fishing industry is considered ***low***, given that it is adaptable to short-term changes brought about by the Project.

*Prevention and Mitigation Measures*

Anadarko proposes the following measures to control and mitigate impacts on local fishing activity:

- Operating 24 hours a day, 7 days a week (weather permitting) to minimize the overall duration of the survey;
- Compliance with Maritime Rules Part 22: Collision Prevention (Maritime NZ, 2009), in terms of the use of obligatory appropriate radio, lights, flags and other visible signals, and good navigational practices and seamanship;
- The presence of a two support vessels during the MSS activities to help ensure that other users of the sea are aware of the presence of the trailing underwater streamers and temporarily relocate any fishing nets or other fishing gear found in the survey area; and
- Warnings of the proposed MSS will be issued (Coastal Navigation Warning) and a vigilant watch (radio, AIS, radar, visual) will be maintained throughout survey activities. Both English and signal code protocols will be employed to allow multi-lingual communication streams.

*Residual Impact*

Although the presence of survey vessels and equipment may create a temporary disturbance to the fishing industry, this impact will be mitigated by the above measures. The residual impact on local fishing activities from MSS activity is considered to be ***negligible.***

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor | Low |
| Significance of impact from MSS activity on local fishing activity and damage to fishing equipment | Negligible |

*Interaction or Interference with Marine Traffic*

An increase in marine traffic increases the risk of interference and possibly collision between vessels during the survey. This could impact upon vessels in the Project Area and those present in the transit route between the Project Area and the nearest port.

The magnitude of this impact is considered to be ***small,*** given that only three vessels will be utilized for the MSS, over a temporary duration. The sensitivity of marine traffic is considered ***low,*** given that it is highly adaptable to short-term changes brought about by the Project and the survey area does not include major shipping routes or areas where navigation is otherwise restricted.

*Prevention and Mitigation Measures*

The mitigation measures discussed in relation to fishing activities are also applicable to reducing the risk of interference and possible collisions with marine traffic during the MSS.

*Residual Impacts*

Implementation of the above measures will mitigate potential risks of vessel collision and interference. The residual impact on marine traffic from MSS activity is therefore considered to be ***negligible***.

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor | Low |
| Significance of impact from MSS activity on marine traffic | Negligible |

*Indirect Effects on Fisheries*

Seismic data acquisition can temporarily alter the behavioral patterns of certain fish species, causing them to move away from the sound source (McCauley *et al.*, 2003). Consequently, this may result in indirect impacts to fishing activity in the Project Area.

Given the temporary nature of the Project and the large alternate areas of identical fish habitat and fishing grounds outside the Project Area, the magnitude of impact to fisheries as a result of changes to fish behavior is considered to be ***small.*** The sensitivity of the fisheries to this impact is considered ***medium*** for the same reasons. .

*Prevention and Mitigation Measures*

The survey will be conducted continuously, reducing the impact period to approximately 42 days, effectively limiting impacts on fish stocks and fisheries activities in the Project Area.

*Residual Impacts*

Although temporary displacement of fish stocks may occur, the overall significance of indirect impacts to fisheries as a result of changes in fish behavior is considered to be ***minor***.

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor | Medium |
| Significance of impact from MSS activity on targeted fish stocks | Minor |

*Change in Marine Bird Behavior*

As discussed in *Section 4.2.8*, the marine waters off NZ support a wide range of marine birds, including a number of threatened species.

During foraging, the potential exists for sea birds to interact with the seismic vessel and support vessels. These interactions may be either beneficial (e.g. through the provision of perch locations) or negative (e.g. injury through collision or entanglement) to sea birds

Artificial lighting can cause disorientation in seabirds, but research suggests that disorientation mainly affects fledglings and novice flyers, particularly when it occurs near shore (Telfer *et al.*, 1987). Artificially lit vessels at sea also have the potential to attract seabirds, but the mechanism through which they are attracted to lit vessels is poorly understood. Sea birds are thought to navigate by starlight over the ocean, and in some cases artificial lights may interfere with seabirds' ability to navigate by stars (Black, 2005; Guynup, 2003). Fish and other foraging species are attracted to the lights as well, and seabirds may be attracted to foraging opportunities around the vessels (Black, 2005).

Risk of entanglement would be greatest if the birds became disoriented or were unable to identify the rigging in flight. Collisions or entanglements in daylight hours are unlikely because most sea birds are agile and have keen eyesight, so would be able to avoid collisions with the vessels. The risk of collision would therefore be greater at night. The design of the in-water survey equipment does not present a risk of entanglement for sea birds.

The magnitude of negative impacts on marine birds from MMS activities is considered to be ***negligible***, as specific impacts will be too low to be measured and within the range of normal natural variation. A degree of positive impact has also been identified through the provision of resting areas in the form of perch space for birds on the open ocean. Due to the threatened status of a number of species identified within the Project Area (e.g. Westland petrel, sooty shearwater, flesh-footed shearwater, Chatham albatross, northern royal albatross and black-browed albatross) the sensitivity of seabirds is considered to be ***medium***.

*Prevention and Mitigation Measures*

The limited duration of the MSS would reduce the potential for long term interference with sea bird navigation. Also, the fact that the vessels would be in constant motion and not generating a food supply would reduce the potential for significant numbers of prey items to congregate around the vessels, reducing the attraction of sea birds to the vessels.

*Residual Impact*

The net effect of the potential positive and negative aspects of these interactions on seabirds in the Project Area will be insignificant, so the proposed MSS will have ***negligible*** effects on seabirds.

| | Residual Impact |
|---|---|
| Magnitude of impact | Negligible |
| Sensitivity of receptor | Medium |
| Significance of MSS activity on marine bird behavior | Negligible |

*Interaction or Interference with Marine Mammals*

As highlighted in *Section 4.2.6*, a number of marine mammals included on the NZ Threat Classification List or as species of concern in the Code may occur in the Project Area. The Project Area is located approximately 15 km from the Clifford and Cloudy Bay MMS, identified as an important area for Hector's dolphins, humpback and southern right whales. The whale watching industry in Kaikoura has high cultural and economic value and there are concerns that the MSS could cause displacement of marine mammals in the region, thus resulting in negative impacts upon the industry. This section covers impacts to marine mammals resulting from the physical interaction with MSS vessels and equipment. Acoustic impacts are discussed separately in *Section 6.2.2*.

Collisions from Project vessels with marine mammals, during transit to and from the project area, are possible. Physical impacts from boat-strikes include the potential for injury, and possibly mortality in severe instances. A global study collated all known ship strikes up until 2002, listing a total of 292 records of confirmed or possible strikes of which 48 were fatal (Jensen & Silber, 2003). Most fatal or serious whale injuries involve strikes from larger vessels (Laist *et al.*, 2001).

Speed is considered a key factor in ship strikes of cetaceans and one study recording the mean speed of the vessels at the point of strike at greater than 18 knots (Jensen & Silber, 2003). It is not expected that any vessels associated with the Project will travel at speeds much greater than ~12 knots. Additionally, there will not be small, fast moving vessels that are more commonly associated with marine mammal disturbance, and intentional approaches of marine mammals by Project vessels will not occur.

Six (6) species of marine mammals (152 individuals) have been positively identified in previous seismic surveys in the Pegasus Basin (refer to *Section 4.2.6*). Although it is unlikely that these species are resident within, or reliant upon any unique characteristics of the Project Area, due to their vulnerability and protected status, marine mammal sensitivity to the physical presence of the MSS vessel and equipment is considered ***medium***.

Given the large area of open water in which the vessels are operating and the temporary nature of the Project, it is expected this impact will be limited to a specific group of localized individuals, travelling through the area at the time of the survey, and any impacts will be limited to the duration of the activity. As such, the overall magnitude of this impact is considered to be ***small***.

*Prevention and Mitigation Measures*

The Project Area is located within the winter migration route of the majority of large whale species. However, as the proposed MSS is scheduled to be undertaken in summer (January 2014), this will not coincide with the whales' annual migration, thus greatly reducing the likelihood of interaction with these species.

To further reduce the probability of interaction with marine mammals the MSS vessels will operate in accordance with the Code. Specifically the vessels will:

- Carry at least two independently trained marine mammal observers (MMO) for the duration of the survey. These MMO will adopt a rotating shift system to ensure that observations are undertaken throughout the MSS and will observe the Code;
- In addition to PAM during day time operations, PAM will also be adopted during night time operations when visual observations of marine mammals will be impaired. Carry at least two PAM operators. The operation of PAM will be integrated within the rotating MMO shift system to maximize coverage and effectiveness of both warning systems;

- Adopt soft start procedures (refer to *Section 6.2.2* for further detail on source sound emissions);
- Adopt stop-work procedures in alignment with the Code, specifically shut down of any Level 1 acoustic source (combine operational capacity exceeding 7 liters/427 cubic inches) if a Species of Concern (defined in *Section 6.2.2* below) is detected within 1 km of the vessel or if a cetacean with a calf is detected within 1.5 km of the vessel;
- Start- up of the acoustic source will be delayed until all marine mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, or continuous observations have been undertaken without detection of marine mammals (for the respective periods stated in the Code);
- Travel no faster than idle or "no wake" speed within 300 m of any marine mammal;
- Not suddenly or repeatedly change the speed or direction of any vessel, except in the case of an emergency;
- Not circle, obstruct the path, or cut through any group of marine mammals; and
- When not operational, keep at least 50 m away from whales (or 200 m from any large whale mother and calf or calves) at all times.

In addition, the cruising speed of the vessel engaged to conduct the MSS program (*MV Duke)* is 10 knots (18.5 km/h). When surveying equipment is in the water, vessel speed will be reduced further (between 3.5 knots (6.5 km/h) and 5.5 knots (10 km/h)). These speeds are below those reported as most likely to result in vessel strikes or cause significant injury upon impact.

These mitigation measures will also be employed to reduce the impacts associated with source sound emission on marine mammals' acoustic communication detailed in *Section 6.2.2*.

*Residual Impacts*

Considering the proactive mitigation measures discussed above, the anticipated impact to marine mammals from the physical presence of the survey vessels is anticipated to be ***minor***.

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor | Medium |
| Significance of impact from interaction or interference with marine mammals | Minor |

### 6.2.2 *Source Sound Emissions*

The sound emissions associated with the proposed MSS have the potential to disturb marine fauna through the following specific impacts:

- Physiological effects (lethal or sub-lethal injuries): potential injury or fatality of marine fauna from exposure to noise or associated pressure effects to nearby organisms;
- Behavioral disturbance leading to behavioral changes or displacement;
- Disruption to feeding, spawning and calving activities of marine fauna in such way as to affect the vitality or abundance of populations, including indirect effects such as changes in the abundance or behavior of prey; and,
- Interference with the use of acoustic communication signals, or naturally produced cues used by marine animals.

The Project is located within an AEI and 15 km from the Clifford and Cloudy Bay MSS. As mentioned above, the whale watching industry in Kaikoura has high economic and cultural value. There are concerns that the MSS could cause displacement of marine mammals which would negatively impact upon this industry.

The Code sets out the requirements for sound transmission loss modelling, which is required for MSS conducted within an AEI. The Code states that *"The results of such modelling should give an indication of the relative distances from the acoustic source over which 171 dB re 1 µPa2-s SEL (behavior criteria) and 186 dB re 1 µPa2-s SEL (injury criteria) could be expected. Depending on the outcomes, if these levels are predicted to occur at greater distances than the relevant mitigation zones (Species of Concern with calves and Other Marine Mammals respectively), then additional mitigation measures such as just described must be discussed with the Department and considered for implementation."* This is a stringent assessment because the values in the guidance are for the most sensitive group of species being pinnipeds in water. Accordingly the modelling was conducted for the frequencies pinnipeds in water are most vulnerable to.

The modelling was conducted for two pseudo-transects that, while unlikely to be specifically conducted as part of the MMS, are broadly representative of the MSS area. A relatively shallow vessel location was assumed for one analysis. This situation is depicted in "Transect 1" (in the Northwest of PEP 54858). Another location, "Transect 2", was chosen to show the extent of the impact of noise in deeper water.

The results for Transect 1 show that the noise will decay to below the criteria of 171 dB re 1 µPa2-s SEL (behavior criteria) at 750 m. The results also show that the 186 dB re 1 Pa2-s SEL (injury criteria) would be met at 200 m. The results for Transect 2 show that the noise will decay to below the criteria of 171 dB re 1 µPa2-s SEL (behavior criteria) at 950 m, and 186 dB re 1 µPa2-s SEL (injury criteria) would be met at 200 m for pinnipeds. A full modelling report is provided in *Annex B*.

Potential exists for MSS operations to have an adverse impact on marine mammals. Potential impacts from seismic operations rest mostly with the larger cetacean species and a few smaller species for which serious conservation concerns exist. *Table 6.3* lists the Species of Concern currently included in Schedule 2 of the Code and specifies those which are likely to occur in the Project Area.

*Table 6.3: DOC Species of Concern*

| Latin Name | Common Name | Presence in Project Area |
|---|---|---|
| *Megaptera novaengliae* | Humpback whale | Possible Presence |
| *Balaenoptera borealis* | Sei whale | Possible Presence |
| *Balaenoptera edeni* | Bryde's whale | Possible presence |
| *Balaenoptera bonaerensis* | Antarctic Minke whale | Possible Presence |
| *Balaenoptera acutorostrata subsp.* | Dwarf Minke whale | Possible Presence |
| *Balaenoptera musculus* | Blue whale | Possible Presence |
| *Balaenoptera physalus* | Fin whale | Possible Presence |
| *Balaenoptera musculus brevicauda* | Pygmy Blue whale | Possible Presence |
| *Eubalaena australis* | Southern Right whale | Possible Presence |
| *Caperea marginata* | Pygmy Right whale | Possible Presence |
| *Lissodelphis peronii* | Southern Right-whale dolphin | Possible Presence |
| *Globicephala melas* | Long-finned Pilot whale | Possible Presence |
| *Globicephala macrorhynchus* | Short-finned Pilot whale | Possible Presence |
| *Peponcephala electra* | Melon-headed whale | Unlikely to Occur |
| *Physeter macrocephalus* | Sperm whale | Possible Presence |
| *Kogia sima* | Dwarf Sperm whale | Possible Presence |
| *Kogia breviceps* | Pygmy Sperm whale | Possible Presence |
| *Mesoplodon grayi* | Gray's Beaked whale | Possible Presence |
| *Berardius arnuxii* | Arnoux's Beaked whale | Possible Presence |
| *Ziphius cavirostris* | Cuvier's Beaked whale | Possible Presence |
| *Mesoplodon layardii* | Strap-toothed whale | Possible Presence |
| *Hyperoodon planifrons* | Southern Bottlenose whale | Possible Presence |
| *Mesoplodon bowdoini* | Andrew's Beaked whale | Possible Presence |

| Latin Name | Common Name | Presence in Project Area |
|---|---|---|
| *Mesoplodon mirus* | True's Beaked whale | Possible Presence |
| *Mesoplodon densirostris* | Blainville's Beaked whale | Possible Presence |
| *Mesoplodon gingkodens* | Ginkgo-toothed whale | Possible Presence |
| *Mesoplodon hectori* | Hector's Beaked whale | Possible Presence |
| *Mesoplodon peruvianus* | Pygmy/Peruvian Beaked whale | Unlikely to occur |
| *Tasmacetus shepherdi* | Shepherd's Beaked whale | Possible Presence |
| *Orcinus orca* | Killer whale | Possible Presence |
| *Pseudorca crassidens* | False Killer whale | Possible Presence |
| *Feresa attenuata* | Pygmy Killer whale | Unlikely to Occur |
| *Cephalorhynchus hectori* | Hector's dolphin | Possible Presence |
| *Cephalorhynchus hectori maui* | Maui's dolphin | Unlikely to Occur |
| *Phocarctos hookeri* | New Zealand sea lion | Unlikely to Occur |
| *Tursops truncatus* | Bottlenose dolphin | Possible Presence |

*Source: DOC, 2013b*

Environmental issues relating to MSS are focused on the potential effects on marine fauna from the sound waves associated with the seismic energy source. The pulses associated with MSS produce 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). There is an instantaneous rise in maximum pressure followed by an exponential pressure decrease and drop in energy.

The low-frequency signals created during MSS events propagate efficiently in the water, with little loss due to attenuation (i.e. due to absorption and scattering). Within a few meters of an airgun array, spherical spreading loss (the reduction in intensity caused by the spreading of waves into an ever increasing space) results in a loss of around 6 dB per doubling of distance. However, attenuation depends on propagation conditions. In good propagation conditions, the signal may be above the background level for more than 100 km; in poor propagation conditions it may reach background level within a few tens of kilometres (McCauley, 1994).

Sound waves travel until they meet an object or they are dissipated by normal decay of the signal. Nevertheless, the intensity of sound waves decays exponentially, and although low level signals travel for long distances, the higher amplitude waves lose much of their energy very close to the airgun source. Typically, most emitted energy is low frequency, between 0.01 to 0.3 kHz, but pulses also contain some higher frequency energy up to 0.5-1 kHz. The latter components are weak when compared to the low frequency emissions (Richardson *et al.*, 1995). The low frequency component of the sound spectrum attenuates slowly, but high frequency sound attenuates rapidly to levels similar to those produced from natural sources. The rate of change in sound level from a seismic airgun is relatively rapid, and it may be this factor, as much as any, which contributes to observed effects on marine organisms.

The exposure time to the airgun signal will be determined by the firing sequence, the towed speed of the airgun through the water, and the sound level of interest. Large mobile fauna such as fish and marine mammals will likely move away from the airgun source at the higher sound levels, thereby reducing their exposure times.

The Project will utilize a maximum seismic source of 3,610 cubic $in^3$, with air guns towed at a depth of 12 m. Air guns will be positioned in a single source array and fired at 25 m intervals (approximately 12 seconds at an operating speed of 8 km/hr). Operating pressure will be 2,000 psi.

*Physiological Effects on Marine Fauna from Exposure to Noise or associated Pressure Effects*

The sound intensities required to produce physiological effects are largely unknown for most marine animals, and what is known is based on a limited number of experiments of varying quality. Impacts on cetaceans however, are better understood. Southall *et al.*, (2007) produced a set of criteria for impacts from noise on cetaceans. The work identified a threshold of > 230 decibels (**dB**) re 1 micro Pascal (**µPa**) (peak) to cause a permanent loss in hearing ability. High sound levels are found only close to the source, and hence the area where damage may occur is limited to close proximity to the source. Therefore, the potential for serious physiological effect would be minor, and immediate physiological effects would be restricted to short ranges and high sound intensities.

Southall *et al.* (2007) report that there is uncertainty in determining thresholds for behavioral responses to noise. Richardson *et al.* (1991) outlines differing responses to noise within individual species groups, with varying responses most likely a result of sex, different activities (foraging, resting, etc.), behavior, individual sensitivities, etc.

A significant population of sperm whales is found in waters off Kaikoura. While this is 200 km southwest of the Project Area, these animals may use offshore waters up to and including the Project Area (see *Section 4.2.6*). Madsen *et al.* (2002) discuss male sperm whale behavior during exposures to seismic surveys. The exposure to low level gun pulses of 146 dB during seismic surveys did not result in observable avoidance behavior nor did the pulses cause changes in the acoustic behavior during foraging. Madsen *et al.* (2002) note, however, that the data of this study should not be extrapolated to the possible effects of seismic pulses with higher received levels.

Another study on the impacts of seismic surveys on sperm whales indicated that sperm whales didn't undertake foraging dives when approached closely by a seismic survey vessel emitting airgun noise (Weilgart 2007). According to DEWHA, (2008), there is currently no evidence to suggest seismic surveys have caused long-term displacement of whales from areas where surveys have been carried out. This report also states that at the scale of a seismic survey, any temporary displacements which may occur are unlikely to cause significant biological cost to the species unless the survey is conducted within an important area or during a critical behavior such as feeding or breeding.

Physiological effects will be unlikely to occur for the majority of species. Most free-swimming animals will avoid noise sources that cause them discomfort before they get within the range at which negative effects may occur. However, animals that do not flee the approaching survey vessel because of behavioral or physical constraints could be at risk of physiological effects. Such animals include plankton, fish eggs and some sessile (i.e. non-mobile) organisms such as marine benthos and some species of fish. The limited number of available studies on representative non-mobile marine fauna have detected no physiological effects on molluscs (Parry *et al.*, 2002) and only minor effects on planktonic crustacean larvae (Levings, 2004). A recent study on the effects of anthropogenic noise on NZ scallop larvae (*Pecten novaezelandia*) by Anguilar de Soto, *et al.* (2013), showed however, that long exposure to seismic sources (in laboratory conditions) can result in delayed development and abnormal growth. This study infers that similar results may be observed in other invertebrate larvae species due to similar growth patterns. Scallops are not listed as significant within the project area (MPI, 2013q) and are not commercially caught in FMA 2; however the normal range for this species lies within the Clifford and Cloudy Bay MMS.

Exposure to elevated noise can lead to threshold shift, or elevation of lower limit of auditory sensitivity, in fish. Studies of captive fish indicate that the severity of threshold shift is directly correlated to the frequency of the noise and duration of exposure. Fathead Minnows (*Pimephales promelus*) are hearing specialists, i.e. they possess particularly acute auditory sensitivity over a wide frequency range and a low hearing threshold due to the presence of accessory structures. Their specialized anatomy suggests that they may be more sensitive to intense noise exposure than fish without this enhanced hearing capability. Skolik and Yan (2002) observed temporary threshold shift in fathead minnows after one hour of exposure to white noise at frequencies above 1 kHz, but no threshold shift at 0.8 kHz. Threshold shift following an hour of exposure at 1000 Hz lasted less than 24 hours. The sound energy associated with the MSS will be below 1 kHz.

Popper *et al.* (2005) found varying degrees of threshold shift in Northern Pike (*Esox lucius*), Broad Whitefish (*Coregonus nasus*), and Lake Chub (*Couesius plumbeus*) after exposure to an operating 730 cubic inches airgun array, but recovery occurred within 24 hours of exposure. These results strongly suggest that the proposed MSS could induce temporary auditory effects on fish near the source, but no lasting physiological effects.

Most studies suggest that seismic effects on benthic invertebrates are minor, and occur primarily in shallow water. These species generally do not have air filled organs (e.g. swim bladders) in their bodies, reducing the potential for impacts relating to pressure changes resulting from the seismic source. Data on the impacts of seismic sound on macro invertebrates (scallop, sea urchins, mussels, periwinkles, crustaceans, shrimp, gastropods, and squid) show that little mortality occurs below sound levels of 220 dB re 1µPa@1m. Some show no mortality at 230 dB re 1µPa@1m (Royal Society of Canada, 2004).

In terms of impacts on corals, it is considered possible that sound could have impacts in certain circumstances, yet studies are rare. In one case study, in Western Australia, a significant and unique survey has been conducted to assess potential acoustic impacts on corals from a seismic survey. The seismic survey was a 3-D survey and was at a minimum depth of 25m; of much greater scale than that of the Project. To conduct the research, five monitoring sites (two exposure and three control) were identified, that contained a range of coral types totaling one hundred different species. Each coral was identified, examined, tagged and photographed, and each of the sites were sampled three times (before exposure to the seismic source; within 96 hours after exposure and five months after exposure). The conclusion of the study was that there were no observed impacts on hard corals as a result of exposure to seismic sound (Taylor *et al.*, 2013).

Impacts from the seismic source will be limited to a specific group of localized individuals present at the time of the survey. These impacts will not flow through into future generations, nor will it significantly impact the overall population of any marine organism. Accordingly, the magnitude of impacts from MSS sound emissions on any receptor is considered to be *small*.

Molluscs, plankton and fish are considered to be of *low* sensitivity due to their abundance and wide distribution. As discussed, marine mammals have a *medium* sensitivity, given their vulnerability and protected status.

*Mitigation Measures*

The Code is designed to minimize acoustic disturbance to marine mammals from seismic operations, including the possible interference with vocalizing cetaceans.

Anadarko will adhere to the stringent requirements of the Code at all times during MSS activity. Specifically, the requirements of the Code will be implemented as follows:

- The MSS vessel will carry at least two independently trained MMO for the duration of the survey;
- In addition to PAM during day time operations, PAM will also be adopted during night time operations when visual observations of marine mammals will be impaired. Carry at least two PAM operators. The operation of PAM will be integrated within the rotating MMO shift system to maximize coverage and effectiveness of both warning systems;
- Soft start procedures will be adopted;
- Adopt stop-work procedures in alignment with the Code, specifically shut down of any Level 1 acoustic source (combined operational capacity exceeding 7 liters/427 cubic inches) if a Species of Concern is detected within 1 km of the vessel or if a cetacean with a calf is detected within 1.5 km;
- Start-up of the acoustic source will be delayed until all marine mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, or continuous observations have been undertaken without detection of marine mammals (for the respective periods stated in the Code);
- Vessels will travel no faster than idle or "no wake" speed within 300 m of any marine mammal;
- Vessels will not suddenly or repeatedly change their speed or direction, except in the case of an emergency;
- Vessels will not circle, obstruct the path, or cut through any group of marine mammals; and
- When not operational, all Project vessels will keep at least 50 m away from whales (or 200 m from any large whale mother and calf or calves) at all times.

Further detail relating to the above can be found in *Section 9* of this EIA.

*Residual Impacts*

The overall significance of impacts on marine mammals from seismic noise and pressure effects is considered to be ***minor.*** The overall significance of impacts on other marine fauna, such as molluscs, plankton, and fish is considered to be ***negligible.***

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor (marine mammals) | Medium |
| Sensitivity of receptor (molluscs, plankton and fish) | Low |
| Significance of noise and pressure impacts on marine mammals | Minor |
| Significance of noise and pressure impacts on molluscs, plankton and fish | Negligible |

*Behavioral Disturbance Leading to Behavioral Changes or Displacement*

Behavioral responses to MSS, including fright, avoidance, and changes in vocal behavior have been observed in Mysticetes (baleen whales) and Odontocetes (toothed whales and dolphins). Studies of the effects of noise from offshore MSS on whales indicate that MSS noise may cause changes in localized movements and behaviors in cetaceans, including swimming away from the source, rapid swimming at the surface, and breaching (McCauley *et al.*, 1998; McCauley *et al.*, 2003), however; MSS noise does not appear to cause changes in the regional migration patterns of cetaceans (McCauley *et al.*, 2003).

Experimental data on survivorship demonstrate high survivorship in squid following exposure to sound levels of 220 dB re 1µPa@1m (Royal Society of Canada, 2004). Cephalopods (octopuses, squids, and cuttlefishes) were historically considered to be deaf, but more recent research has indicated that some species exhibit behavioral responses to acoustic stimuli (Komak *et al.*, 2005).

A recent study of the effects of seismic noise on squid behavior documented startle and alarm responses, but also suggested little change in auditory thresholds over time (McCauley *et al.*, 2003). Cuttlefish have been shown to respond in a variety of ways to vibrations in a wide range of frequencies from 0.02-0.6 kHz, however it is currently unclear whether the responses observed indicated alarm or distress. No empirical data is available on arrow squid's ability to detect sound, but extrapolation from studies on cuttlefish and other squid species indicate that they may exhibit some behavioral response to vibrations in their immediate vicinity, but that mortality is generally unlikely as a result of loud noise events.

The magnitude of impact from seismic noise on the behavioral responses of marine fauna is considered to be ***small***, given that effects will be localized and of a temporary duration.

As discussed, the sensitivity of molluscs and other invertebrates is considered to be *low*, given their lack of air-filled organs, abundance and wide distribution, while marine mammals are of *medium* sensitivity due to their vulnerability and protected status.

*Prevention and Mitigation*

The Code is designed to minimize acoustic disturbance to marine mammals from seismic operations, including the possible interference with vocalizing cetaceans.

Anadarko will adhere to the stringent requirements of the Code at all times during MSS activity. Specifically, the requirements of the Code will be implemented as follows:

- The MSS vessel will carry at least two independently trained MMO for the duration of the survey;
- In addition to PAM during day time operations, PAM will also be adopted during night time operations when visual observations of marine mammals will be impaired. Carry at least two PAM operators. The operation of PAM will be integrated within the rotating MMO shift system to maximize coverage and effectiveness of both warning systems;
- Soft start procedures will be adopted;
- Adopt stop-work procedures in alignment with the Code, specifically shut down of any Level 1 acoustic source (combined operational capacity exceeding 7 liters/427 cubic inches) if a Species of Concern is detected within 1 km of the vessel or if a cetacean with a calf is detected within 1.5 km;
- Start-up of the acoustic source will be delayed until all marine mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, or continuous observations have been undertaken without detection of marine mammals (for the respective periods stated in the Code);
- Vessels will travel no faster than idle or "no wake" speed within 300 m of any marine mammal;
- Vessels will not suddenly or repeatedly change their speed or direction, except in the case of an emergency;
- Vessels will not circle, obstruct the path, or cut through any group of marine mammals; and
- When not operational, all Project vessels will keep at least 50 m away from whales (or 200 m from any large whale mother and calf or calves) at all times.

Further detail relating to the above can be found in *Section 9* of this EIA.

*Residual Impacts*

It is anticipated that noise associated with the MSS will have a ***minor*** impact on the behavioral patterns of marine mammals if the above mitigation measures are adhered to.

Similarly, ***negligible*** impacts are anticipated on the behavioral patterns of molluscs from MSS noise.

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor (marine mammals) | Medium |
| Sensitivity of receptor (molluscs) | Low |
| Significance of impact from MSS noise on marine mammal behavior | Minor |
| Significance of impact from MSS noise on mollusc behavior | Negligible |

*Interference with the Use of Acoustic Communication Signals, or Naturally-Produced Cues Used by Marine Animals*

The most studied, and best understood, examples of acoustic communication in the marine environment are cetacean vocalizations. Cetaceans emit noise for the purposes of communication and navigation. MSS could have significant impacts on cetaceans' ability to use these signals if the sounds associated were in the same frequency range as the sounds generated by the cetaceans, and interfered with or obscured signals in areas that are biologically significant to cetaceans.

*Table 6.4* summarizes the known frequencies of echolocation and communication calls for selected cetaceans that could be present in the Project Area at the time of the survey. The table illustrates that the known spectrum of echolocation signals are at higher frequencies (2-130 kHz) than the high end of the operational range of seismic sources (1 kHz). The range of frequencies used by cetaceans for communication is generally lower than the range of frequencies used for echolocation, so the greatest potential for interference would occur at the highest end of the seismic spectrum and the lowest end of whales' and dolphins' communication spectrum.

*Table 6.4: Frequencies of Cetacean Communication and Echolocation Vocalizations*

| Species | Communication Call Frequency Range (kHz) | Echolocation Frequency Range (kHz) |
|---|---|---|
| Bottlenose dolphin | 0.8-24 | 110-130 |
| Common dolphin | 0.2-16 | 23-67 |
| Hector's dolphin | Average >82, mean 124.2 | |
| False killer whale | 4-30 | 25-30, 95-130 |
| Killer whale | 0.5-25 | 12-25 |
| Long-finned Pilot whale | 1-18 | 6-117 |
| Sperm whale | 0.1-30 | 2-30 |
| Blue whale | 0.018–0.1 | - |

*Source: Richardson et al. (1995), McCauley et al. (2001), and Dawson and Thorpe (1990)*

There is good evidence to suggest that baleen whales are particularly susceptible to disturbance from MSS. These whales are thought to be sensitive to frequencies as low as 0.01 kHz. Their vocalizations typically occur in the 0.01 to 0.3 kHz frequency range (Richardson *et al.*, 1995).

Acoustic masking may occur over large areas for baleen whales, particularly those that communicate in the lowest frequency ranges (i.e. blue whales) (DOC, *pers. comm.*). Marine mammals are likely to practice avoidance techniques during the MSS. Although potentially disrupting normal behavior, this will ultimately limit their exposure to the seismic source and reduce the risk of physiological effects.

The MSS will utilize airgun volumes from 40 to 300 cu in, with a cumulative source volume of 3,610 cu in. Operating pressure will be 2,000 psi. The seismic source will be fired at 25m intervals, at an operating speed of 8 km/hr. This will result in a shot being fired approximately every 12 seconds.

As shown in *Figure 6.1*, most acoustic energy emitted from airguns during deep-water surveys is between approximately 10 and 300 Hz (0.01 – 0.3 kHz). According to Richardson *et al.* (1995) this is below the lower frequency limits of most toothed whales, but directly comparable to the vocalization range of baleen whales. Of the toothed whales listed in *Table 6.4* only the Sperm whale and Common dolphin communicate at sufficiently low frequencies (0.1- 30 kHz) to be affected by the frequencies most commonly emitted during deepwater MSS. Both these species have been identified in the Pegasus Basin during a seismic survey conducted in 2009-10 (MED 2010).

However, despite this partial overlap in frequency range, the magnitude of impact on marine mammals' ability to communicate via acoustic signals is considered to be *small*, given that only a specific group of localized individuals will be affected over a short time period.

As discussed, marine mammal sensitivity to MSS is considered to be *medium* given their low abundance and protected status.

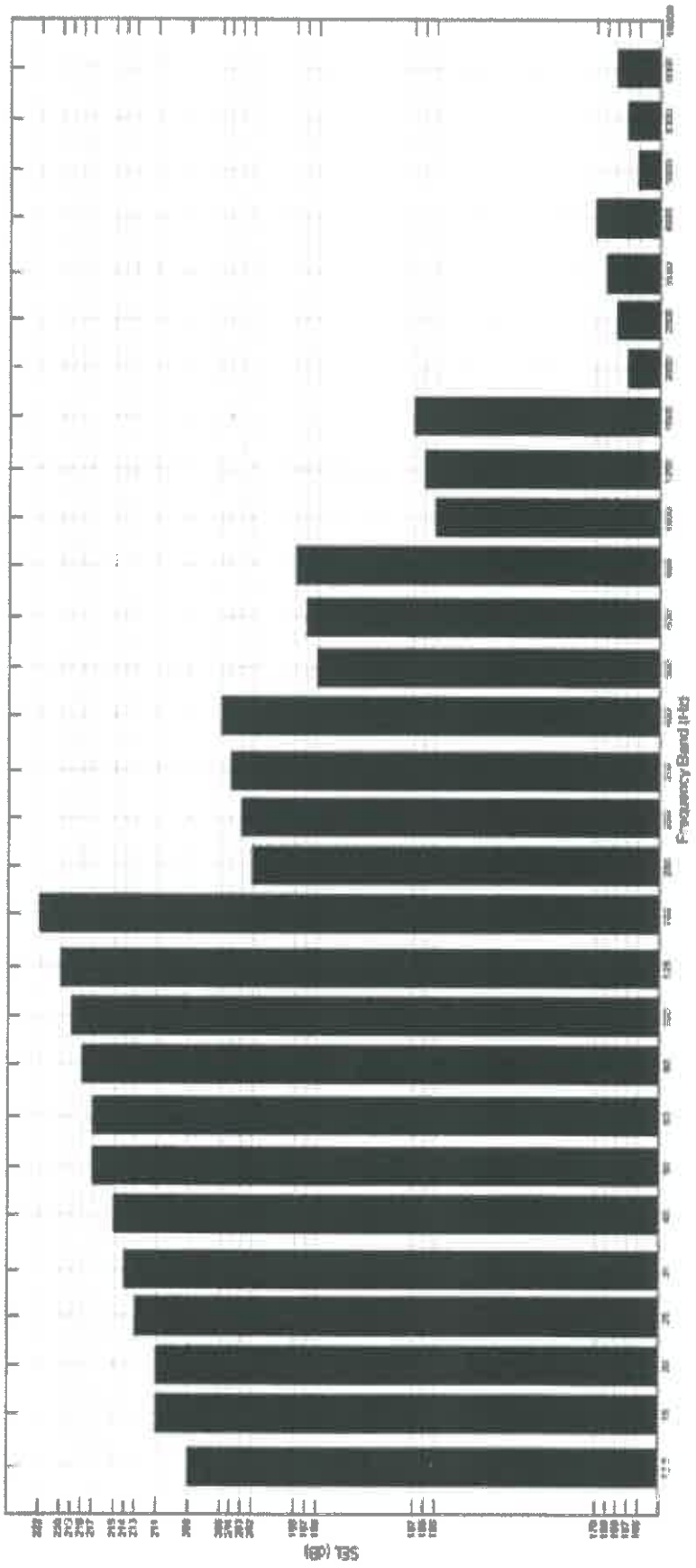


*Figure 6.1: SEL Source Spectrum based on Thompson's Spectral Estimation*

*Prevention and Mitigation*

The Code is designed to minimize acoustic disturbance to marine mammals from seismic operations, including the possible interference with vocalizing cetaceans.

Anadarko will adhere to the stringent requirements of the Code at all times during MSS activity. Specifically, the requirements of the Code will be implemented as follows:

- The MSS vessel will carry at least two independently trained MMO for the duration of the survey;
- In addition to PAM during day time operations, PAM will also be adopted during night time operations when visual observations of marine mammals will be impaired. Carry at least two PAM operators. The operation of PAM will be integrated within the rotating MMO shift system to maximize coverage and effectiveness of both warning systems;
- Soft start procedures will be adopted;
- Adopt stop-work procedures in alignment with the Code, specifically shut down of any Level 1 acoustic source (combined operational capacity exceeding 7 liters/427 cubic inches) if a Species of Concern is detected within 1 km of the vessel or if a cetacean with a calf is detected within 1.5 km;
- Start-up of the acoustic source will be delayed until all marine mammals detected within the relevant mitigation zones are observed moving beyond the respective areas, or continuous observations have been undertaken without detection of marine mammals (for the respective periods stated in the Code);
- Vessels will travel no faster than idle or "no wake" speed within 300 m of any marine mammal;
- Vessels will not suddenly or repeatedly change their speed or direction, except in the case of an emergency;
- Vessels will not circle, obstruct the path, or cut through any group of marine mammals; and
- When not operational, all Project vessels will keep at least 50 m away from whales (or 200 m from any large whale mother and calf or calves) at all times.

Further detail relating to the above can be found in *Section 9* of this EIA.

*Residual Impacts*

**Considering the above mitigation measures, including soft-starts and the use of PAM/MMOs, MSS activities are considered to have *minor* effects on marine mammals' use of naturally-produced acoustic signals.**

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor | Medium |
| Significance of impact from MSS noise on marine mammal communication | Minor |

*Disruption to Feeding, Spawning and Calving Activities of Marine Fauna*

*Table 6.5* **summarizes the presence of commercially important fish and listed marine mammal species within the Project Area, based on the known parameters of each species' life history.**

*Table 6.5: Presence of Commercially Important Fish, Listed Marine Mammals and Species of Concern within the Project Area, during Different Life History Stages*

| Species | Feeding | Spawning/Calving | Migration |
|---|---|---|---|
| Hoki | Year round | Winter | - |
| Alfonsino | Year round | No data | - |
| Ling | Year round | Spring - Summer | - |
| Black cardinal fish | Year round | Autumn+ | - |
| Orange roughy | Year round | Winter | - |
| Tarakihi | Year round | Summer - Autumn | - |
| Hake | Year round | Winter - Spring | - |
| Scampi | Year round | Spring - Summer | - |
| Deepwater crabs | Year round | Summer - Autumn | - |
| Sperm whale | Year round | Year round | Winter |
| Pygmy sperm whale | Year round+ | No data | - |
| Blue whale | - | - | Winter |
| Pygmy blue whale | Year round+ | No data | No data |
| Antarctic minke whale | - | - | Winter |
| Fin whale | Year round+ | - | Winter+ |
| Humpback whale | - | - | Winter |
| Sei whale | - | - | Winter |
| Beaked whales* | Year round | Year round+ | - |

| Species | Feeding | Spawning/Calving | Migration |
|---|---|---|---|
| Southern right whale | Summer | Winter | - |
| Pygmy right whale | Year round | No data | - |
| Southern bottlenose whale | Year round | Year round+ | - |
| Bryde's whale | Year round | No data | No data |
| Southern right whale dolphin | Year round+ | No data | - |
| Dusky dolphin | Year round | - | - |
| Common dolphin | Year round | Winter+ | - |
| Bottlenose dolphin | Year round | Year round | - |
| Hectors dolphin | Year round | - | - |
| Killer whale | Year round | Year round+ | - |
| False killer whale | Year round | Year round+ | - |
| Long-finned pilot whale | Year round | Year round+ | - |
| Short-finned pilot whale | Year round | Year round+ | - |
| NZ fur seal | Year round | Summer | - |

*Notes:*

** Seven species of beaked whale are included in the Code.*

*+ Based on limited data for these species.*

*Source: refer to Section 4.2 for full reference details.*

Although a number of marine mammals listed as species of concern in the Code could be present in the Project Area during MSS activities, effects would be primarily related to the disturbance of feeding activities. This includes indirect effects, such as changes to the abundance or behavior of prey.

However, no location-specific feeding aggregations have been identified within the Project Area and species would be expected to relocate to unaffected areas during the survey. Predatory species would likely adjust their behaviors and distributions to react to new patterns of prey availability, thus preserving their ability to forage.

One commercially important fish species (ling) and two benthic species (scampi and deepwater crabs) are reported to use the Project Area for spawning habitat over summer, when the MSS program is scheduled. A review of the effects of seismic testing on marine fish and fisheries has been conducted by Tenera Environmental (2011). This study reported that larvae close to the surface where the air gun array is towed could be affected by seismic activity. However, the potential for impacts on fish resources is determined by the habitat distributions and life histories of those species likely to be exposed to the sound sources. Species least likely to be affected include deep dwelling soft bottom species and open water species that may occasionally occur within the project boundaries but have primary seasonal occurrences well offshore.

Scampi and crabs are benthic species, which would limit their direct exposure to air gun emissions. As discussed in *Section 4.2.3*, ling are open water species that are widely distributed around NZ. The Chatham Rise has been reported as an important spawning habitat for this species (outside of the Project Area), and they are predominately bottom dwellers. This suggests that the Project Area is not a key spawning ground and MSS operations will have little effect on the national populations of these species.

The magnitude of impact from MSS on the important life stages of marine fauna is therefore considered to be ***negligible***, given the schedule of the proposed MSS and the wide distribution of the commercially important fish species and listed marine mammals above. These species are expected to relocate to unaffected areas during the survey, therefore impacts are likely to be too small to be measured or within the range of normal natural variation.

Fish are considered to have ***low*** sensitivity to the above impact due to their high abundance and wide distribution. Marine mammals have a ***medium*** sensitivity, given their relatively low abundance and protected status.

### *Prevention and Mitigation*

No deliberate measures will be implemented to minimize disruption to the life history stages of marine fauna during the MSS. However, the timing of the proposed MSS program (summer), will not coincide with important biological periods identified for the above listed marine mammals.

### *Residual Impacts*

Given that the MSS program will not coincide with important biological periods of listed marine mammals, the MSS is likely to have a ***negligible*** effect on the basic life histories of these species.

The MSS is also likely to have a ***negligible*** effect on the basic life histories of commercially important fish species.

| | Residual Impact |
|---|---|
| Magnitude of impact | Negligible |
| Sensitivity of receptor (marine mammals) | Medium |
| Sensitivity of receptor (fish species) | Low |
| Significance of impact from MSS on the basic life history of marine mammals | Negligible |
| Significance of impact from MSS on the basic life history of commercially important fish species | Negligible |

### 6.2.3 *Solid and Liquid Wastes Generated on the Vessels*

MSS have the potential to impact the marine environment through generation of garbage, sewage and galley wastes on the vessels while at sea.

Various types of waste may be produced, each of which requires proper handling and disposal. The volume of waste generated during the proposed MSS will depend upon duration, and the number of crew on board each vessel (seismic and support vessels). As such, the following impact assessment has been based on the typical MSS elements detailed in *Section 3*. Specifically a total combined crew of 38 persons (for the *MV Duke* and support vessels) for the Project duration of 42 days.

#### *Sanitary and Domestic Wastewater*

It is assumed that one person generates 100 l/day of sanitary wastewater (from toilet facilities) and 220 l/day of domestic wastewater ("grey water" from showers, sinks, laundries, and galleys, as well as from safety shower and eye-wash stations). It is predicted that sanitary wastes will have an associated BOD of 240 mg/l.

*Table 6.6* shows the estimated amount of sanitary and domestic wastewater that will be generated on the MSS vessel and the associated Biological Oxygen Demand (**BOD**), using the above assumptions, given estimated 38 persons on board and a MSS program duration of 42 days.

*Table 6.6: Estimated Amounts of Sanitary, Domestic Wastewater and BOD per day for MSS Operations of 42 days*

| Personnel on Board: 38<br>Length of Operations | Sanitary Waste (l) | BOD (kg) | Domestic Waste (l) |
|---|---|---|---|
| 1 day | 3,800 | 0.912 | 8,360 |
| 42 days | 159,600 | 38.3 | 351,120 |

Such discharges will create a local level of biological and chemical oxygen demand due to the elevated presence of microorganisms and organic material. In accordance with MARPOL Annex IV, sanitary wastes will be processed using an international maritime organization (IMO)-compliant on board sewage processing facility, to ensure the 5-day average BOD is maintained at < 25 mg/l. Due to the localized nature of this impact and the short duration of the activity, the magnitude of this impact is considered to be ***negligible***.

The sensitivity of the water column to these impacts is rated as ***low*** given the volume of the surrounding ocean environment, which typically is subject to high wave energy that will promote dilution and mixing, within which these discharges will quickly diffuse.

Fish may be attracted to waste discharges generated by the MSS vessels. Fish may be exposed to localized and temporary reductions in water quality in the immediate area of the discharge prior to dilution. However, given the wide distribution and high abundances of fish species that may be present in the area, the sensitivity of fish to MSS vessel discharges is considered ***low***.

### *Prevention and Mitigation Measures*

To mitigate potential impacts, effluent will be treated by Anadarko to meet MARPOL Annex IV requirements prior to discharge into the sea. As per MARPOL Annex IV, the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land. Sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land.

Food wastes will also be discharged in accordance with MARPOL Annex V requirements directly to the sea following maceration. All food waste will be macerated into small pieces (<25 mm diameter) prior to discharge.

### *Residual Impacts*

Considering the rapid dilution and dispersion that will occur in the open sea and the discharge standards that will be adhered to, the residual impact from sanitary and domestic wastewater discharges on seawater quality is considered to be ***negligible.***

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor (seawater quality) | Low |
| Sensitivity of receptor (fish) | Low |
| Significance of impact on seawater quality from sanitary and domestic wastewater discharge | Negligible |

*Discharge of Bilge and Drainage Waters*

Drainage water on the MSS vessels can originate from various sources, including:

- Rainfall (deck runoff);
- Deck washing;
- Clean area floor drains;
- Overflow drains;
- Machinery area floor drains;
- Bilge; and
- Bunded areas beneath fuel and chemical storage areas (potentially containing oil).

Drainage and bilge water will be directed to a holding tank then routed through an oil/water separator and monitored for oil concentration before discharge. The content of oil contaminated water that may be discharged to the marine environment is controlled under MARPOL Annex I, with oil-in-water concentrations not to exceed 15 ppm. Based on a maximum concentration of 15 ppm oil-in-water, any impact will be highly localized to the immediate area of the discharge point, and there would be no visible sheen. Accordingly, the magnitude of this impact is considered to be ***negligible***.

The sensitivity of the water quality within the Project Area is considered to be ***low***, given the high dilution and dispersion levels of the open ocean environment where the survey will take place.

*Prevention and Mitigation*

Mitigation measures to reduce the impacts from discharges of bilge and drainage water are inherent in the project design or required by regulation including:

- All deck drainage from areas that may be contaminated will be directed to bilges for treatment prior to discharge.
- Bilge waters from machinery spaces are pumped to holding tanks, filtered, and discharged overboard with oil in water levels of less than 15 ppm (in accordance with MARPOL). Separated oil sludge will be temporarily stored and properly disposed ashore.
- Any waste oil transfers will be logged and recorded in the vessels' Oil Record Book and all transfer records held for the required period.

- Vessels will maintain a valid International Oil Pollution Prevention (**IOPP**) Certificate and Oil Record Book (**ORB**) and will have on board IMO-type approved oily water separators and piping arrangements.

*Residual Impact*

Following this process, the amounts of oil within the drainage waters will be very small and considering dilution and dispersion effects, it is expected that there will be a ***negligible*** impact on sea water quality.

| | Residual Impact |
|---|---|
| Magnitude of impact | Negligible |
| Sensitivity of receptor (water quality) | Low |
| Significance of drainage water discharge on water quality | Negligible |

### 6.2.4 *Atmospheric Emissions*

Air emissions generated during the MSS program include greenhouse and acidic gases, which have the potential to impact air quality on a local and global scale.

The principle sources of air emissions are exhaust gases from the vessel engines, the air compressor generators, and the on board waste incinerator. An estimate of the fuel consumption from the engine and generator operations, for one seismic vessel and two support vessels, during mobilization and demobilization, and for survey operations with the Project Area is presented in *Table 6.7*.

The *MV Duke* is capable of cruising at approximately 10 knots (18.5 km/h) when in transit with no equipment deployed. When surveying equipment is in the water, vessel speed will likely be no less than 3.5 knots (6.5 km/h) and no more than 5.5 knots (10 km/h). For the purpose of this estimate, it has been assumed that the average operating speed for the vessel during the MSS would be 6.3 knots (11.7 km/h).

An estimate of the total fuel use has been made based on the following assumptions:

- Average daily fuel use for a typical seismic vessel during seismic operations is estimated as 11 $m^3$ per day during MSS. Greater efficiencies are assumed during transit to and from the Project Area, with an estimated fuel use of 9 $m^3$ per day;

- Mobilization/de-mobilization to/from the Project Area is assumed to take approximately 1 day on each journey. Similarly, return to port from the Project Area for resupply/ bunkering is assumed to take 1 day and will occur once during the MSS;

- The MSS will take a maximum of 42 days; and

- For a typical support vessel, the average daily fuel consumption is estimated to be 0.8 $m^3$ per day.

*Table 6.7: Estimated Fuel Consumption*

| Vessel | Activity | Days | Average Fuel Consumption (tons/day)* | Fuel Consumption (tons) |
|---|---|---|---|---|
| Seismic Vessel | Mobilization and transit to Project Area | 1.0 | 8.01 | 12.0 |
| | Seismic acquisition | 42 | 9.79 | 490 |
| | Transit to port for refueling/resupply | 2.0 | 8.01 | 24 |
| | Demobilization | 1.0 | 8.01 | 12.0 |
| Two support vessels | Mobilization and transit to Project Area | 1.0 | 0.71 | 2.14 |
| | Seismic acquisition | 42 | 0.71 | 71.2 |
| | Transit to port for refueling/resupply | 2.0 | 0.71 | 4.28 |
| | Demobilization | 1.0 | 0.71 | 2.14 |
| **Total** | | | | **617.7** |

*Notes:*
* *1l of marine gas fuel = approximately 890 g*

Estimation of the predicted emissions associated with the MSS program outlined in *Table 6.7* has been made using emission factors based on methodology proposed by the International Association of Oil and Gas Producers (Exploration and Production Forum, 1994). *Table 6.8* summarizes the predicted emissions associated with the MSS.

*Table 6.8: Total Air Emission Estimates for the Project Area MSS*

| Emission Gas | Emissions Factors (Sea transport) | Gas Emitted (tons) |
|---|---|---|
| Carbon Dioxide | 3.2 | 1847 |
| Carbon Monoxide | 0.008 | 4.62 |
| Nitrogen Oxides | 0.059 | 34.1 |
| Nitrous Oxide | 0.00022 | 0.13 |
| Sulfur Dioxide | 2x S* | 17.3 |
| Methane | 0.00027 | 0.16 |
| Volatile Organic Compounds | 0.024 | 13.9 |

*Notes:*
* *Assumes a sulfur content for marine gas oil of 1.5% by weight*

*Source: Exploration and Production Forum (1994)*

The magnitude of impacts on air quality is considered to be *small*, as there will be a slight change expected over a limited area, with air quality returning to background levels within a few meters. The calculated emissions would be insignificant compared with general emissions from maritime traffic in the vicinity of the Project Area.

The sensitivity of air quality is *low*, given that the existing air quality of the Project Area is good and the ecological resources it supports (marine birds) are not sensitive to such a localized change in air quality.

### *Prevention and Mitigation Measures*

Practical steps to limit atmospheric emissions will be undertaken on the vessels during the seismic operations and will include:

- Proper maintenance of equipment and generators; and
- Regular monitoring of fuel consumption.

### *Residual Impacts*

Available data show that dispersion of these emissions will be rapid and background levels reached within a few hundred meters from the source.

Given the transient nature of the survey operations, the volatility of the air emissions, and the sea winds, emissions would be expected to undergo rapid dispersion, resulting in *negligible* impacts on air quality, including their contribution to greenhouse and acidic gases in the atmosphere.

| | Residual Impact |
|---|---|
| Magnitude of impact | Small |
| Sensitivity of receptor (air quality) | Low |
| Significance of impact on air quality from MSS atmospheric emissions. | Negligible |

## 6.3 ASSESSMENT OF IMPACTS FROM ACCIDENTAL EVENTS

Accidental events are generally rare during MSS operations, but any marine operation poses a small potential risk of an accident at sea. An assessment of the potential for accidental events was conducted to cover their possible occurrence.

### 6.3.1 *Introduction of Invasive Marine Species*

Marine organisms can be inadvertently introduced via hull fouling and ballast water discharges, particularly from chase/support vessels which travel long distances from survey to survey. The spread of invasive marine species poses a biosecurity threat, and could lead to the disturbance of native species and/or marine ecosystems. A successful invasion could result in widespread and long-term/permanent changes to local biodiversity. Accordingly the severity of this potential impact is considered to be ***high***.

#### *Prevention and Mitigation Measures*

Commercial survey vessels have their hulls cleaned regularly and are treated with antifouling paints to prevent the establishment and growth of fouling communities. This means that the presence of fouling communities and any pests the vessels may include is usually much less on commercial survey vessels than on smaller or non-commercial vessels.

No vessel involved in MSS activities will discharge any ballast water within 12 nautical miles of the NZ coast in compliance with the *Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993)*, so the potential to introduce marine organisms to NZ's coastal waters through ballast water exchange will be very remote. NZ biosecurity legislation and requirements for inspection of vessels will be adhered to for all vessels involved in the MSS.

Accordingly the likelihood of invasion from pest species as a result of the Project is considered to be ***extremely unlikely***.

#### *Residual Impact*

While the severity of this impact could be ***high***, given the above mitigation measures, the likelihood of it occurring is considered to be ***extremely unlikely***. As a result, the overall impact significance is reduced to ***ALARP***.

| | Residual Impact |
|---|---|
| Severity of potential impact | High |
| Likelihood of potential impact | Extremely Unlikely |
| Significance of introduction of invasive marine species | ALARP |

### 6.3.2 *Streamer Cable Break and Cable Release*

The risk of damage to a streamer depends on the hazards in the area. A streamer may be damaged by tangling during rough weather; snagging with floating debris; or rupturing from abrasions, animal bites, or collisions. There are several reported incidents of sharks and seals attacking MSS equipment and severing the plastic streamer lines that contain electrical insulating fluid, resulting in leaks.

The total loss of a streamer is considered improbable, and loss of part, or all, of the streamer would have little impact on the marine environment other than potential entanglement hazards and loss of a small volume of streamer fluid. Streamers are solid and buoyant so if a break should occur they would not pose a risk to benthic habitats. If a broken streamer is not recovered however, streamers may become tangled in fishing nets or ship propellers.

#### *Mitigation Measures*

The release of streamer fluid after a break and subsequent chemical impacts on water quality will be dependent on the contents of the streamer and the quantity of release. As the *MV Duke* is equipped with a solid foam streamer system, there will be no risk of fluid leakage or release if a streamer is damaged.

All streamers will be kept in good condition and stored appropriately. Only qualified technicians will deploy or retrieve streamers and will adhere to strict handling guidelines. A fast workboat will be available at all times to assist in retrieval and management of streamers.

#### *Residual Impacts*

Should a streamer section break, the resultant impact is expected to be minimal and of a temporary duration. As such, the severity of such potential impacts is considered to be ***low***. With the above mitigation measures in place, the possibility of such an event occurring is considered ***unlikely*** and the overall impact significance is considered to be ***ALARP***.

| | Residual Impact |
|---|---|
| Severity of potential impact | Low |
| Likelihood of potential impact | Unlikely |
| Significance of impact from streamer cable break | ALARP |

### 6.3.3 *Fuel/Oil Spill from Vessels*

The key potential accidental events identified for the MSS are fuel spills from sources on the seismic and support vessels. The most likely unplanned spill or release during survey operations is the accidental spillage of fuel products during transfer operations. Spill volumes for this kind of unforeseen event are typically small, ranging from a few liters however bunkering spills may be more substantial. Spillage may also occur as a result of leaking equipment storage containers or accidental releases from unsecured containers. Such spills are typically small-volume spills and are often entirely contained on the vessel, or if they do reach the sea, are typically less than 50 l.

A worst-case scenario would involve partial or complete loss of either the vessel's fuel inventory following rupture of the vessel's tank(s) in a collision. The maximum possible spill size would be the total loss of the entire fuel capacity and would only occur in the event of a complete failure of the fuel tanks. *MV Duke* has a fuel capacity of 660 $m^3$. Spills of this type only occur as a result of catastrophic loss of hull integrity or complete failure of the vessel's fuel containment system, and are extremely rare due to the navigational systems on board and the environmental procedures in place on the vessels.

A larger spill has the potential to affect local fish populations, seabirds, and marine mammals including the potential for direct toxicity where oil is ingested, fouling of birds and seals leading to loss of waterproofing and the potential for hypothermia and drowning, and inhalation of vapors by surface breathing mammals. If a spill were to occur close to shore, coastal habitats and communities could also be affected.

*Prevention and Mitigation Measures*

A number of specific measures will be implemented to eliminate or minimize the risk of spills and potential impacts arising from refueling operations. Vessel-to-vessel oil transfer and refueling operations at sea will not be undertaken during the Project, thus avoiding fuel spillages during transfer operations.

A Ship Oil Pollution Emergency Plan (**SOPEP**) will be in place for all vessels. The SOPEPs provide oil pollution control procedures, and complete copies of the SOPEPs will be kept on board for the duration of the survey. The SOPEPs have been certified as consistent with MARPOL Annex I requirements, and guidelines developed by the International Maritime Organization.

In addition to the SOPEPs, the engaged seismic contractor will be required to develop a Project Specific EHS Plan which includes procedures to be used in the event of an emergency.

Spills of a significant quantity of oil/fuel as a result of accidents, refueling operations, or vessel collisions are considered *Unlikely* due to the stringent safety and maritime requirements that will be implemented during the survey. With the implementation of the above mitigation measures, the severity of an impacts from the accidental spill of fuel, oil or chemicals, is considered to be *Low*.

As a result, the overall impact significance from the accidental spill of fuel, oil or chemicals is reduced to *ALARP*.

| | Residual Impact |
|---|---|
| Severity of impact | Low |
| Likelihood of impact | Unlikely |
| Significance of fuel spill impacts | ALARP |

### 6.3.4 *Vessel Collision or Sinking*

In the unlikely event that the seismic vessel or support vessels sink and/or are damaged in a collision, the principal environmental impacts are anticipated to arise from the vessel and the on board materials, such as oil and lubricants stores and lithium batteries coming into contact with the sea floor.

The quantities of the hazardous materials carried on the vessels are relatively small and are likely to be rapidly dispersed should accidental spillage occur. The severity of potential impacts arising from vessel collision or sinking is therefore considered to be *low*.

#### *Prevention and Mitigation Measures*

Risks associated with loss of life resulting from vessel sinking are reduced through the presence of two or more vessels at the site during MSS, meaning each is able to provide immediate assistance to the other vessel.

The Project will comply with *Maritime Rules Part 22: Collision Prevention* (Maritime NZ, 2009), in terms of obligatory appropriate radio, navigational aids and good navigational practices and seamanship. The presence of two or more vessels will strengthen the above.

Accordingly, the likelihood of this potential impact occurring is considered to be *unlikely*.

*Residual Impacts*

With the implementation of the above mitigation measures, the severity of impacts from vessel collision or sinking is considered to be *low* and the likelihood of such an event occurring is considered to be *unlikely*. As a result, the overall significance of impacts associated with vessel collisions is considered to be *ALARP*.

| | Residual Impact |
|---|---|
| Severity of impact | Low |
| Likelihood of impact | Unlikely |
| Significance of collision impacts | ALARP |

### 6.3.5 *Impacts of Natural Disasters*

NZ straddles an active tectonic plate boundary and as such its coastal communities are vulnerable to earthquake and tsunami hazards (NIWA, 2009). Recent incidents with the Asia-Pacific region have also further highlighted the potential for tsunami/earthquake events originating in the Pacific Rim to affect NZ waters. The impacts of such incidents on off-shore temporary activities such as MSS are, however, considered to be limited, particularly given the anticipated water depths within the Project Area. In addition, the major potential impacts resulting from natural disaster events would be spills (oil and fuel) and/or vessel sinking, both of which are considered to have *low* severity of impacts. However, such an occurrence is considered to be *extremely unlikely* and the overall significance is considered to be *ALARP*.

| | Residual Impact |
|---|---|
| Severity of impact | Low |
| Likelihood of impact | Extremely unlikely |
| Significance of natural disaster impacts | ALARP |

## 6.4 *CUMULATIVE IMPACTS*

Cumulative impacts on environmental resources may result from incremental effects of an action, when combined with other past, present, and reasonably foreseeable future projects in the area.

The Pegasus Basin is currently undeveloped and commercial fishing has been identified as the only existing industry present in the Project Area. The use of the Pegasus Basin for this activity during and after the MSS program is not anticipated to be affected. These aspects, combined with the limited overall impact significance, discussed previously in this document, make it unlikely for the Project to contribute to any significant cumulative impact. The addition of the MSS activities is unlikely to provide any measurable cumulative impacts or additive effect and therefore is likely to be insufficient in scale and scope to mark a discernible increase in impacts against the baseline.

Anadarko will however still seek to limit adverse environmental and socioeconomic impact through the use of Best Management Practices and numerous 'designed in' mitigation measures. Anadarko recognizes its activities may possibly result in residual impacts and therefore intends to institute the prescribed mitigation measures described herein. The result of this will be predominantly negligible impacts with limited potential of contributing to the long term cumulative impacts within the Project Area.

# 7 SUMMARY OF ENVIRONMENTAL IMPACTS

*Table 7.1* summarizes the project activities, associated impacts, and impact mechanisms identified in this assessment.

*Table 7.1: MSS Activities and Associated Impacts*

| Aspect or Source | Potential Impact | Magnitude / Severity of Event | Sensitivity of Receptor / Likelihood of Event | Proposed Monitoring or Mitigation Measures | Residual Outcome /Impact |
|---|---|---|---|---|---|
| *Routine Activities* | | | | | |
| Physical presence of survey vessel, streamer, and support vessels | Physical interference with local fishing activities and damage to fishing equipment | Small | Low | 24/7 operations (weather permitting) to minimize overall duration of survey.<br>Compliance with Maritime Code to Avoid Collisions.<br>Presence of two support vessels.<br>Coastal navigation warning.<br>Compliance with COLREGS and *Maritime Rules Part 22: Collision Prevention.*<br>Good navigational practices and seamanship. | Negligible |
| | Interaction or interference with marine traffic | Small | Low | | Negligible |
| | Indirect effects to fisheries | Small | Medium | 24/7 operations (weather permitting) to minimize overall duration of survey | Minor |
| | Change in marine bird behavior | Negligible | Medium | 24/7 operations (weather permitting) to minimize overall duration of survey | Negligible |
| | Interaction or interference with marine mammals | Small | Medium | Adherence with the Code. Specifically:<br>• Use of MMOs;<br>• Use of PAM;<br>• Use of soft start procedures;<br>• Stop work procedures; and<br>• Restrictions on speed and course of vessel. | Minor |

| Aspect or Source | Potential Impact | Magnitude / Severity of Event | Sensitivity of Receptor / Likelihood of Event | Proposed Monitoring or Mitigation Measures | Residual Outcome / Impact |
|---|---|---|---|---|---|
| Source sound emissions | Physiological effects on marine fauna from exposure to noise or associated pressure effects | Small | Low - Medium | Survey schedule (summer) does not coincide with the annual migration period of large whale species through the Project Area.<br>Adherence with the Code. Specifically:<br>• Use of MMOs;<br>• Use of PAM;<br>• Use of soft start procedures;<br>• Stop work procedures; and<br>• Restrictions on speed and course of vessel. | Negligible - Minor |
| | Behavioral disturbance leading to behavioral changes or displacement | Small | Low - Medium | | Negligible - Minor |
| | Interference with the use of acoustic communication signals, or naturally produced cues used by marine animals | Small | Medium | | Minor |
| | Disruption to feeding, spawning and calving activities of marine fauna | Negligible | Low - Medium | 24/7 operations (weather permitting) to minimize overall duration of survey | Negligible |
| Solid and liquid wastes generated on the vessels | Sanitary and domestic wastewater and solid wastes | Small | Low | Effluent treated to meet MARPOL requirements prior to discharge to sea.<br>Maceration of food wastes and discharge in accordance with MARPOL. | Negligible |
| | Discharge of bilge and drainage waters | Small | Low | Collection and treatment of potentially contaminated drainage water.<br>Bilge waters filtered and treated to MARPOL requirements. | Negligible |

| Aspect or Source | Potential Impact | Magnitude / Severity of Event | Sensitivity of Receptor / Likelihood of Event | Proposed Monitoring or Mitigation Measures | Residual Outcome /Impact |
|---|---|---|---|---|---|
| | | | | Waste oil transfers logged.<br>Vessels will maintain a valid IOPP certificate and ORB. | |
| Atmospheric emissions | Air emissions | Small | Low | Proper maintenance of equipment and generators.<br>Regular monitoring of fuel consumption | Negligible |
| *Non-Routine and Accidental Events* | | | | | |
| Introduction of marine pests | Water quality impact.<br>Displacement of native species and/or marine ecosystems. | High | Extremely unlikely | No MSS vessel will discharge ballast waters within 12 nautical miles of the coast, in accordance with the *Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993).* | ALARP |
| Streamer cable break and cable content release | Water quality impact.<br>Entanglement of marine fauna.<br>Interference with fishing equipment or propellers. | Low | Unlikely | Use of solid, neutrally-buoyant streamers.<br>Support vessels will help minimize potential for other vessels to damage the streamer.<br>Streamers will be kept in good condition and stored appropriately.<br>Streamers to be deployed by qualified technicians and strict handling guidelines adhered to. | ALARP |

| Aspect or Source | Potential Impact | Magnitude / Severity of Event | Sensitivity of Receptor / Likelihood of Event | Proposed Monitoring or Mitigation Measures | Residual Outcome / Impact |
|---|---|---|---|---|---|
| Fuel spill from seismic vessels | Water quality impact.<br>Adverse effects on marine fauna (e.g. fouling, inhalation of vapors, direct toxicity).<br>Coastal habitats and communities adversely affected if spill occurs close to shore. | Low | Unlikely | No bunkering or oil transfers will take place at sea.<br>SOPEP in place for all vessels.<br>Project specific EHS plan implemented by seismic contractor.<br>Compliance with Maritime Code to Avoid Collisions<br>Presence of support vessels<br>Coastal navigation warning | ALARP |
| Vessel collision or sinking | Disruption of seafloor sediments and benthic communities. Release of hazardous substances. | Low | Unlikely | Compliance with Maritime Code to Avoid Collisions<br>Presence of support vessels<br>Coastal navigation warning | ALARP |
| *Natural Disasters* | | | | | |
| Tsunami, earthquake etc. | Spills (oil and fuel) and/or vessel sinking. | Low | Extremely unlikely | - | ALARP |

# 8 ENVIRONMENTAL MANAGEMENT PLAN

## 8.1 INTRODUCTION

The management of environmental risks associated with Anadarko's activities is integral to Anadarko's business decision-making processes. Environmental hazards are identified during planning and throughout operations, and their associated risks are assessed and managed via a structured Pathway to Excellence EHS management system (**P2E**). This is the mechanism that ensures that Anadarko's standards are maintained, the commitments specified in this EIA are met, and that unforeseen aspects of the proposed MSS program are detected and addressed.

An EMP is integral to implementation of Anadarko's P2E program for the proposed project activities. This plan will detail regulatory requirements and commitments outlined in this EIA, along with monitoring and reporting requirements.

## 8.2 IMPLEMENTATION

Contractors are expected to operate a management system that is consistent with the requirements and provisions of Anadarko's P2E program. To ensure contractor performance, Anadarko will:

- Assess contractor environmental performance prior to contract execution;
- Include clauses in contract documents specifying contractor responsibilities and expected environmental performance;
- Indicate requirements for contractor training; and
- Include requirements for sharing information between Anadarko and the contractor, such as the provision of weekly waste generation reports.

Some of the control mechanisms, already in place within Anadarko, are implemented through the EMP and include:

- EHS requirements for contractors;
- A waste accounting system;
- A waste management plan; and
- An Emergency Response Plan, including oil and fuel spills.

To verify the EMP and any specific monitoring is properly implemented during the MSS program, a rigid and defined set of operating procedures will be in place, including proper training, awareness sessions, and communication to all relevant crew and staff. In addition, the contractor will have an EHS representative on board to verify all EHS standards and procedures are followed.

Specific personnel will have designated responsibilities with regard to environmental protection, including supervision and execution of the EMP. The Master will have ultimate responsibility for ensuring the vessel is operated with due regard for environmental protection.

Project contractors will have the responsibility to ensure that all crew members and relevant shore-based managers have received appropriate education and training in order to carry out their duties associated with the MSS activities, in a safe, healthy, and environmentally responsible manner. During all MSS activities, a log will be kept detailing each day's progress and events.

The selected contractors will operate in compliance with Anadarko's environmental policy, P2E program, and with all recommendations and commitments stated in this EIA. Standards and guidelines will be drawn from (but not limited to) the following:

- MfE and Maritime NZ's *Environmental Best Practice Guidelines for the Offshore Petroleum Industry;*
- Guidance provided within current and developing NZ marine legislation, such as the *EEZ Act*, the *Health and Safety in Employment (Petroleum Exploration and Extraction) Regulations 2013*; and
- All relevant Maritime and Marine Protection Rules.

## 8.3 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

In particular, and embedded within the above mentioned management framework, a monitoring program (part of the EMP) will be followed during the proposed MSS program. The following does not include requirements for the management of marine mammals. Given the significance of these impacts, a separate section addressing the management of these impacts can be found in *Section 9*.

The EMP highlights the key environmental aspects for the Project, and sets out the specific mitigation measures and monitoring programs to be followed.

The measures have been designed to eliminate, offset, or reduce any identified adverse environmental impacts to a level that is as low as reasonably practicable. The EMP is consistent with Anadarko's environmental policy commitments, and industry practices and guidelines.

The main goals of the EMP are to:

- Provide a framework for implementing proposed mitigation measures for MSS activities;
- Evaluate effectiveness or inefficiency of these mitigation measures and, if required, modify them or include new mitigation/preventive measures; and
- Ensure that actions and procedures implemented for the MSS activities fulfil environmental regulations required by applicable legislation.

The specific actions to be included in the EMP are detailed in the following subsections.

### 8.3.1 *Actions for Commercial Fishing and Shipping Lanes*

Due to possible interaction with commercial fishing, the EMP will provide a mechanism to comply with NZ's *Maritime Transport Act 1994*. The EMP will ensure that the proposed relevant preventive measures for both pre-survey (information to Port authorities and where applicable to fishing associations) and during MSS activities (support vessel investigation and warning actions) are fully implemented.

The control measures to eliminate or minimize potential effects from the proposed Project activities on fisheries in the Project Area are:

- Completion of project activities in the most efficient manner possible, with 24/7 operations (weather permitting);
- Issuance of warnings of the proposed project activities (Coastal Navigation Warning) and notification of port authorities and where applicable, to fishing associations;
- Compliance with Maritime Rules Part 22: Collision Prevention (Maritime NZ, 2009), in terms of use of obligatory appropriate radio, lights, flags and other visible signals, and good navigational practices and seamanship; and
- Maintenance of a vigilant watch for all maritime vessels and associated equipment, and notification of approaching vessels or static vessels in the Project Area to avoid the MSS equipment (e.g. seismic streamers) using the appropriate signals in accordance with International Maritime Law.

### 8.3.2 *Actions for Controlling Marine Pests*

To reduce the potential for marine pest introduction, antifouling systems will be implemented on all survey vessels. Ballast water regulations will also be strictly adhered to and regular maintenance of all vessels in advance of the MSS activities will be undertaken. NZ biosecurity legislation and requirements for inspection of vessels will be adhered to for all vessels involved in the Project.

### 8.3.3 *Actions for Marine Water Quality*

Potential impacts on water quality from discharges of sewage, sanitary wastes, oily wastes, cooling water, run-off water and other discharges will be controlled through the implementation of good vessel operating procedures for handling liquids and controlling discharges. The key control measures will include:

- The survey vessels will carry out activities in compliance with MARPOL and the NZ *Maritime Transport Act 1994*;
- The waste management plan will be designed and conducted according to standard MARPOL regulations and the applicable provisions of the NZ *Maritime Transport Act 1994*;
- Treated water will be discharged to the sea in accordance to the above international standards, NZ regulations, Anadarko's P2E requirements, and the provisions of NZ's *Marine Transport Act 1994* and the *RMA 1991*;
- Used oil and oil/water mixtures from the vessels will either be stored on board—for eventual recycle/reuse onshore at an approved facility—or incinerated on board. Equipment used to treat and store these materials will be maintained and operated to equipment specification; and
- Monitoring procedures will be in place on board in accordance with MARPOL, and NZ's Environmental Best Practices Guidelines for the Offshore Petroleum Industry.

The EMP provides a mechanism to verify that liquid and solid wastes are stored, handled, and disposed of according to national and international legislation, and company procedures.

### 8.3.4 *Actions for Atmospheric Emissions*

To minimize the impacts of atmospheric conditions, proper maintenance of equipment and generators should be undertaken. Regular monitoring of fuel consumption will also assist in the identification of operational inefficiencies that could be generating excess emissions.

### 8.3.5 *Actions for Accidental Events*

MSS activities will be completed in the most efficient manner possible, with 24/7 operations (weather permitting) to minimize the potential for accidental events to occur.

SOPEPs will be developed for each vessel.

*Maritime Rules Part 22: Collision Prevention* (Maritime NZ, 2009) will be strictly adhered to and the presence of support vessels will minimize the potential for collisions and subsequent fuel release. Coastal navigation warnings will also be issued and 24/7 operations are planned to reduce the overall duration of the survey.

A summary of the EMP with its corresponding recommended measures is presented in *Table 8.1*.

*Table 8.1: Environmental Management Plan*

| Objectives | Parameters to be Controlled | Control Frequency | Proposed Actions | Legislation and Protocols to be Applied |
|---|---|---|---|---|
| Minimize interference with local fisheries and maritime traffic<br>Minimize indirect effects on fisheries | Presence of fishing boats<br>Presence of vessels | Continuous | 24/7 operation (weather permitting) to minimize overall Project duration<br>Coastal navigation warning.<br>Presence of two support vessels.<br>Compliance with COLREGS and *Maritime Rules Part 22: Collision Prevention*<br>Good navigational practices and seamanship. | Best practice<br>*Maritime Rules Part 22: Collision Prevention* |
| Minimize disruption to marine mammals (physical effects of survey vessel and source sound emissions) | Presence of marine mammals within a distance of the survey vessels | Continuous | 24/7 operations (weather permitting) to minimize overall duration of survey<br>MSS does not coincide with annual migration of large whale species through the Project Area.<br>Adherence with the Code. Specifically:<br>• Use of MMOs;<br>• Use of PAM;<br>• Use of soft start procedures;<br>• Stop work procedures; and<br>• Restrictions on speed and course of vessel.<br>See *Section 9* for further detail. | *2013 DOC Code of Conduct to Minimise Acoustic Disturbance to Marine Mammals* |

| Objectives | Parameters to be Controlled | Control Frequency | Proposed Actions | Legislation and Protocols to be Applied |
|---|---|---|---|---|
| Minimize effects on sea water quality | Sanitary and domestic wastewater and solid wastes | Continuous | Effluent treated to meet MARPOL requirements prior to discharge to sea.<br>Maceration of food wastes and discharge in accordance with MARPOL.<br>Recycle/Reuse at an approved shore reception facility in compliance with legal procedures and maintain a log. | MARPOL<br>*Marine Transport Act 1994*<br>*RMA 1991* |
| | Discharge of bilge and drainage waters | Continuous | Collection and treatment of potentially contaminated drainage water.<br>Bilge waters filtered and treated to MARPOL requirements.<br>Waste oil transfers logged.<br>Vessels will maintain a valid IOPP certificate and ORB. | MARPOL<br>*Marine Transport Act 1994*<br>*RMA 1991* |
| Minimize effects on air quality | Atmospheric emissions | Continuous | Proper maintenance of equipment and generators.<br>Regular monitoring of fuel consumption. | Best practice |
| Minimize accidental events<br>Minimize introduction of marine pests | Vessel collisions<br>Fuel/oil spills. | Continuous | 24/7 operations (weather permitting) to minimize MSS duration<br>No bunkering or oil transfers to take place at sea.<br>Project specific EHS plan implemented by seismic contractor.<br>Compliance with Maritime Code to Avoid Collisions<br>Presence of support vessels<br>SOPEP in place on all vessels as part of ERP | Best Practice<br>*Maritime Rules Part 22: Collision Prevention* |
| | Streamer cable break and fluid release | Continuous | Use of solid, neutrally-buoyant streamers.<br>Support vessels will help minimize potential for other vessels to damage the streamer.<br>Streamers will be kept in good condition and stored appropriately.<br>Streamers to be deployed by qualified technicians and strict handling guidelines adhered to. | |

| Objectives | Parameters to be Controlled | Control Frequency | Proposed Actions | Legislation and Protocols to be Applied |
|---|---|---|---|---|
| | Vessel collision or sinking | Continuous | Compliance with Maritime Code to Avoid Collisions<br>**Presence of chase/support vessels**<br>Coastal navigation warning | Best Practice<br>***Maritime Rules Part** 22: Collision Prevention* |
| | Hull fouling<br>Ballast water discharge | Continuous | No MSS vessel will discharge ballast waters within 12 nautical miles of the coast, in accordance with the *Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993).* | Best practice<br>*Import Health Standard for Ships' Ballast Water from All Countries (Biosecurity Act 1993)* |

# 9 MARINE MAMMAL MITIGATION PLAN

## 9.1 OVERVIEW

Anadarko proposes to undertake a 2D MSS within the NZ Block PEP 54858 and 54861 of the Pegasus Basin. The proposed MMS is scheduled to commence in mid-January 2014, over a period of approximately 42 days.

Anadarko is a signatory to the Code.

This Marine Mammal Mitigation Plan (**MMMP**) has been prepared to demonstrate how the requirements of the Code will be implemented on-board the vessel during the MSS, including protocols that will be followed to minimize impacts on marine mammals.

The measures detailed below will be implemented in full throughout the MSS.

## 9.2 LEVEL ONE SURVEY REQUIREMENTS

### 9.2.1 *Pre-Survey Planning*

Anadarko are required to produce and submit an MMIA to the DOC Director-General one month prior to commencing seismic activities. This MMIA fulfils this requirement.

Anadarko has agreed to also provide a copy of this MMIA to Ngati Kuri, once accepted by DOC.

### 9.2.2 *Observer Requirements*

The minimum qualified observer requirements will be:

- At all times there will be at least two qualified MMOs on board;
- At all times there will be at least two qualified PAM operators on board. Details of the PAM system to be used during the MMS are provided in Annex C and are considered appropriate by Anadarko's MMO contractor, GardlineCGG to meet the requirements of the Code;
- The qualified observers will be dedicated in that their roles on the vessel are strictly for the detection and data collection of marine mammal sightings, and instructing crew on their requirements when a marine mammal is detected within the relevant mitigation zone, and
- 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.

Observations by qualified observers will be encouraged at all other times where practical and possible.

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; and,
- 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.

### 9.2.3 *Pre-Start Observations*

#### *Normal Requirements*

The acoustic source will 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 the below *Delayed Starts and Shutdowns* section.

The source will not 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 both binoculars and the naked eye, and no marine mammals (other than fur seals) have been observed in the relevant mitigation zone for at least 30 minutes, and no fur seals have been observed in the relevant mitigation zones for at least 10 minutes, and
- Passive Acoustic Monitoring for the presence of marine mammals has been carried out by a qualified PAM operator for at least 30 minutes before activation and no vocalizing cetaceans have been detected in the relevant mitigation zones.

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

- PAM 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 vocalizing cetaceans in the relevant mitigation zones.

*Additional Requirements for Start-up in a New Location in Poor Sighting Conditions*

In addition to the normal pre-start observation requirements outlined above, when arriving at a new location in the survey program for the first time, the initial acoustic source activation will 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.

### 9.2.4 *Delayed starts and shutdowns*

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

If, during pre-start observations or while a Level 1 acoustic source is activated (which includes soft starts), a qualified observer detects at least one cetacean with a calf within 1.5 km of the source, start up will be delayed or the source will be shut down and not be 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 km*

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

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

*Other Marine Mammals within a Mitigation Zone of 200 m*

If, during pre-start observations prior to initiation of 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.

## 9.3 COMMUNICATIONS FLOW

*Figure 9.1* summarizes the communications process between the MMO and survey personnel in the event of marine mammal sightings.

Anadarko will ensure that communication is possible between the MSS vessel and Whale Watch Kaikoura at all times during the MSS program. Anadarko will also ensure that there is ongoing communication with Ngati Kuri in terms of timing and content around planned activities.

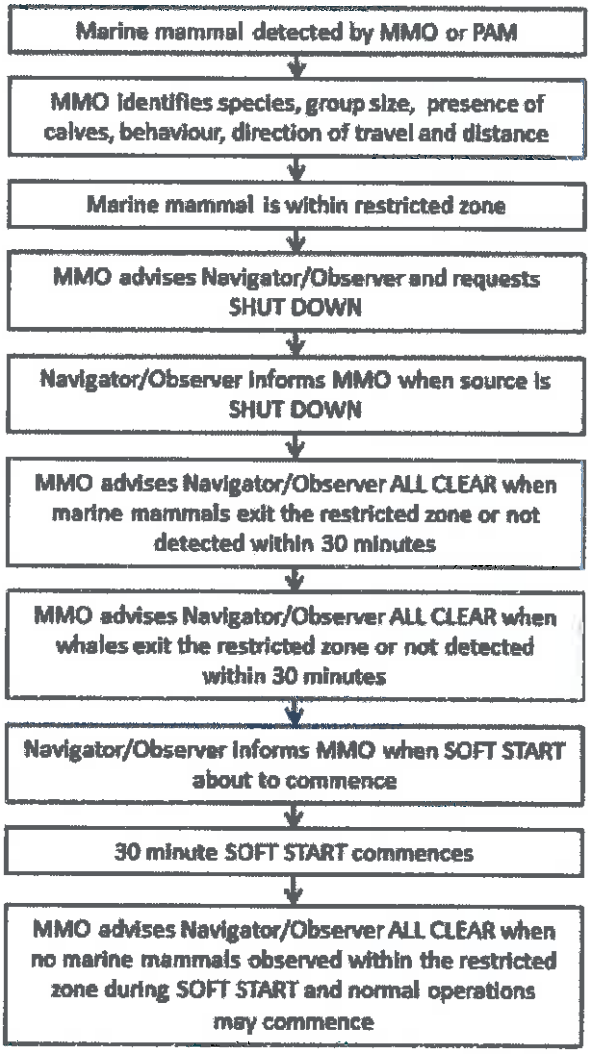



*Figure 9.1 Communication Process in the Event of Marine Mammal Sighting*

## 9.4 MARINE MAMMAL OBSERVER AND PASSIVE ACOUSTIC MONITOR OPERATOR TRAINING AND EXPERIENCE

Prior to commencing the Survey, the MMO and PAM Operators will have:

- Successfully completed the respective marine mammal observation course or PAM operator course recognized by the Director-General as being consistent with DOC standards, or
- Demonstrated all required competencies through an assessment process recognized by the Director-General as being consistent with DOC standards; and
- Logged a minimum of 12 weeks' relevant sea-time engaged in marine seismic survey operations in NZ continental waters, either as an MMO or PAM operator under the supervision of an appropriately qualified observer.

No survey vessel crew will be considered as qualified observers irrespective of training or experience.

PAM operators with 3 years' professional experience and a minimum of 12 weeks' relevant international sea-time may be engaged if no other suitable qualified observer is available.

## 9.5 OPERATIONAL DETAILED REQUIREMENTS

### 9.5.1 *Observer Effort*

While two qualified MMO will be on board at all times, as a minimum one will be on watch during daylight hours while the acoustic source is in the water in the operational area. Of the two qualified PAM operators will also be on board at all times, and a minimum of one will be on watch while the acoustic source is in the water in the operational area.

One qualified observer and one trained observer in each observation role (MMO/PAM) may be on board. In such an instance, an appropriately qualified observer will act in a mentoring capacity to a trained observer for the duration of the MSS.

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

So long as it does not cause health and safety issues, both qualified MMO will be on watch during pre-start observations during daylight hours, or at any other key times where practical and possible.

If one of the MMO with adequate understanding of the PAM system in operation is not required for visual observation duties, they may provide temporary cover in place of a qualified PAM operator to ensure continuation of 24-hour monitoring. This strictly limited exception will only be applied in order to allow for any necessary meal or refreshment breaks. In such an occurrence, a direct line of communication will be maintained between the MMO and the supervising PAM operator at all times. Furthermore, the qualified PAM operator will remain ultimately responsible for the duration of the duty watch.

The maximum on-duty shift duration for observers will not exceed 12 hours in any 24-hour period and the schedules will provide for completion of reporting requirements detailed in *Section 9.3.11*.

### 9.5.2 *Marine Mammal Observer Duties*

While acting in their designated role, MMOs will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for on board operations;
- Continually scan the water surface in all directions around the acoustic source (not the vessel) for presence of marine mammals, using a combination of the naked eye and high-quality binoculars, from optimum vantage points for unimpaired visual observations with minimum distractions;
- 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 throughout the duration of sightings;
- Record and report all marine mammal sightings, including species, group size, behavior/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 the Director-General via Anadarko to clarify any uncertainty or ambiguity in application of the Code;
- Record and report any instances of non-compliance with the Code; and

- Notify the Director-General immediately if higher numbers of cetaceans and/or species of concern are encountered than predicted in the MMIA and in the event of a non-compliance with the Code.

### 9.5.3 *Passive Acoustic Monitor Operator Duties*

While acting in their designated role, PAM operators will:

- Give effective briefings to crew members, and establish clear lines of communication and procedures for on board operations;
- Deploy, retrieve, test and optimize hydrophone arrays;
- On duty watch, concentrate on continually listening to received signals and/or monitoring PAM display screens in order to detect vocalizing 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 discernible, identification of species or cetacean group, position, distance and bearing from vessel and acoustic source;
- Record type and nature of sound, time and duration heard;
- Record general environmental conditions;
- Record acoustic source power output while in operation, and any mitigation measures taken;
- Communicate with the Director-General, via Anadarko, to clarify any uncertainty or ambiguity in application of the Code; and
- Record and report any instances of non-compliance with the Code.

### 9.5.4 *Authority to Shut Down or Delay Starts*

Any qualified observer on duty will have the authority to delay the start of operations or shut down an active survey according to the provisions of this MMIA.

Where MMO are supported by PAM or other alternative technology operators during surveys, marine mammal detections by any means will initiate a process of dialogue between the qualified observers on duty at the time. Such dialogue will ensure that decisions potentially affecting survey operations are made in a robust and mutually supportive manner, based on the skills, experience, capability and professional judgment of the observers. However, either qualified observer has the authority to act independently in each instance, if necessary.

As cetacean calves may be present during the survey, vocalizing cetacean detections by PAM will be assumed to be emanating from a cow/calf pair. In this case the more stringent mitigation zone provisions will be applied, unless determined otherwise by the MMO during good sighting conditions.

Due to the limited detection range of current PAM technology for ultra-high frequency cetaceans (<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'.

### 9.5.5 *Observer Deployment*

The preference for operational deployment of observers is on the seismic vessel. However, if there are critical operational constraints in positioning observation teams on the seismic vessel, they may be redeployed onto the support vessels providing that their ability to perform in their specific roles is not compromised and they will remain in direct communications with the seismic vessel. The qualified observers affected will be involved in any discussions in this regard and agree to any redeployment arrangements. The Director-General must give approval for the observers to be re-deployed prior to any such action being taken.

### 9.5.6 *Crew Observations*

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

In the event that the MMO is not able to view the animal, they will provide a sighting form to the crew member and instruct them on how to complete the form. Vessel crew can relay either the form or basic information to the MMO. If the sighting was within the mitigation zones, it is at the discretion of the MMO whether to initiate mitigation action based on the information available.

Sightings made by members of the crew will be differentiated from those made by MMOs within the reports.

### 9.5.7 *Acoustic Source Power Output*

Anadarko 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.

Anadarko will immediately notify the qualified observers if operational capacity is exceeded at any stage.

### 9.5.8 *Soft Starts*

Acoustic sources 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 respective mitigation zones. This means a gradual increase of the source's power, starting with the lowest capacity gun, over a period of at least 20 minutes and no more than 40 minutes.

The 10-minute break exception from soft start requirements by sporadic activation of acoustic sources at full or reduced power within that time will not be repeated.

Soft starts will be scheduled so as to minimize, as far as possible, the interval between reaching full power operation and commencing a survey line.

### 9.5.9 *Acoustic Source Tests*

Seismic source tests will be subject to the relevant soft start procedures for each survey level, though the 20-minute minimum duration does not apply. Where possible, power will be built up gradually to the required test level at a rate not exceeding that of a normal soft start.

If undertaken, seismic source tests with a maximum combined source capacity of <2.49 liters or 150 cubic inches, will not be subject to soft start procedures, and will be undertaken following relevant pre-start observations.

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

### 9.5.10 *Line Turns*

If possible and practical, Anadarko will shut down at the end of a line and reactivate the acoustic source according to the applicable soft start procedures and pre-start observations, in accordance with the Code.

### 9.5.11 *Recording and Reporting Requirements*

All sightings of marine mammals during the survey period, including any beyond the maximum mitigation zone boundaries or while in transit, will be recorded in a standardized format. A written trip report will be submitted by Anadarko to the Director-General no longer than 60 days after completion of the survey. In addition, weekly reports will be provided by the MMO's to Anadarko.

Recording and reporting of observations of other marine species will also be taken.

In addition to the above summary report, the qualified observers will submit all raw datasheets directly to the Director-General, no longer than 14 days after completion of each deployment. Anadarko understands that proprietary information provided to the Director-General through these reporting processes will be treated in confidence. Only data on marine mammal detections will be made publicly available, primarily in summary form through updates to information resources for Areas of Ecological Importance, but potentially also for detailed analytical research.

Anadarko has agreed to provide copies of MMO monitoring reports to Ngati Kuri at completion of the MSS.

The Director-General will be informed immediately, via Anadarko, if the qualified observers consider that higher numbers of cetaceans and/or Species of Concern than predicted in the MMIA are encountered at any time during the survey. In such instances where the Director-General determines that any additional measures are necessary, these will be implemented without delay. The Director-General will also be informed immediately about any instances of non-compliance with the Code.

DOC will also be notified immediately, via Anadarko, of any Hector's and/or Maui's dolphin sightings by phone (DOC National Office: Ian Angus, Iangus@doc.govt.nz, 04 471 3081 (office), and DOC Taranaki Area Office: Callum Lilley, clilley@doc.govt.nz, 06 759 7169 (office), /or Bryan Williams, bwilliams@doc.govt.nz, 06 759 7174 (office),

### 9.5.12 *Additional Commitments Requested by DOC*

APC will consider covering the cost for necropsies for marine mammals that strand in the area of the survey on a case by case basis in consultation with DOC.

### 9.5.13 *Report Contents*

The following will be included in the trip report being produced:

- The identity, qualifications and experience of those involved in observations;
- Observer effort, including totals for watch effort (hours and minutes);
- Observational methods employed;
- Name of the operator and any vessels/aircraft used;
- Specifications of the seismic source array, and PAM array;
- Position, date, start/end of survey, GPS track logs of vessel movements;
- Totals for seismic source operations (hours and minutes) indicating respective durations of full-power operation, soft starts and acoustic source testing, and power levels employed, plus at least one random soft start sample per swing;
- Sighting/acoustic detection records indicating:
    - Method of detection;
    - Position of vessel/acoustic source;
    - Distance and bearing of marine mammals related to the acoustic source;
    - Direction of travel of both vessel and marine mammals;
    - Number, composition, behavior/activity and response of the marine mammal group (plotted in relation to vessel throughout detection);
    - Confirmed identification keys for species or lowest taxonomic level;
    - Confidence level of identification;
    - Descriptions of distinguishing features of individuals where possible;
    - Acoustic source activity and power at time of sighting;
    - Environmental conditions;
    - Water depth, and
    - For PAM detections, time and duration heard, type and nature of sound.

- General location, time, duration and reasons where observations were affected by poor sighting conditions;
- Position, time and number of delays and shutdowns initiated in response to the presence of marine mammals;
- Position, duration and maximum power attained where operational capacity is exceeded;
- Any instances of non-compliance with the Code, and
- Differentiation will be made between data derived from:
    - MMO and PAM operators;
    - Qualified observers and others; and
    - Watches during survey operations (ON Survey) or at other times (OFF Survey).

Data will be recorded in a standardized format, which can be downloaded from the DOC website at http://www.doc.govt.nz/notifications.

# 10 CONCLUSION

Project activities within the oil and gas sector have well-established standard procedures to mitigate the potential impacts resulting from the MSS activities. As highlighted previously, these recommended management controls and mitigation measures will be implemented throughout the duration of the MSS program within the Project Area.

A number of potential site-specific sensitive receptors and existing interests have been identified in the vicinity of the Project Area; however the overall environmental impacts associated with the proposed MSS program, taking into consideration the management and mitigation measures outlined in this EIA, are considered to be *negligible* or *minor*.

## 11 REFERENCES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Annex A

# Consultation Details


NYSE: APC

# NEW ZEALAND SEISMIC SURVEY FACT SHEET

## About Anadarko

Anadarko is committed to safely producing the energy our world needs in a manner that protects the environment and public health, and supports our communities. Among the world's largest independent oil and natural gas exploration and production companies, Anadarko's employees worldwide share a commitment to always act with integrity and trust, servant leadership, a commercial focus and open communication, and a belief that energy is fundamental to physical existence; as important as clean air, water and food.

## Environmental Commitment

Safety and environmental protection are paramount for Anadarko. When undertaking a new project, Anadarko works to engage stakeholders to gain a clear understanding of the environmental and cultural considerations of an area. Then, the company creates a balanced plan to protect the locations in which it operates and applies the strictest of standards; international standards, an individual country's regulations, or our own policies and principles.

## New Zealand Operations

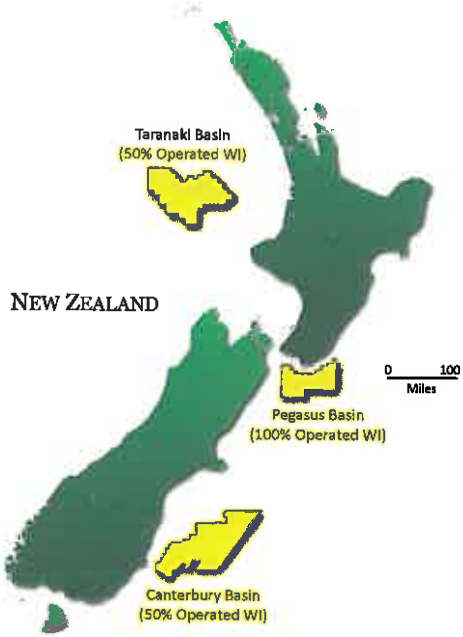
Anadarko has been actively investing in New Zealand since 2008. We have established an office in Wellington and are advancing exploratory programmes in both deepwater Taranaki and the Canterbury Basin, where we expect to test two exploratory prospects in late-2013/2014.

In December 2012, the New Zealand Government announced the awarding of two additional petroleum exploration permits to Anadarko in the Pegasus Basin, which is located South East of the Wairarapa. The next step is to continue the extensive science work, desktop and geological surveys to gain a clear picture of the environment and the rock formations that exist thousands of feet beneath the seabed.

All of the science requires a significant investment of time and any testing of identified prospects will only occur years from now, pending the results of our analysis.

While there is still a lot of exploration work and analysis to be done, we are optimistic about the potential our activities present for New Zealand's future.

Among Anadarko's core values is Servant Leadership, defined as placing the success of others above our own. This describes our approach to the sustainability of our operations. We look to extend success beyond our commercial interests, to our human interests, and we look forward to delivering real gains for New Zealand's economy.



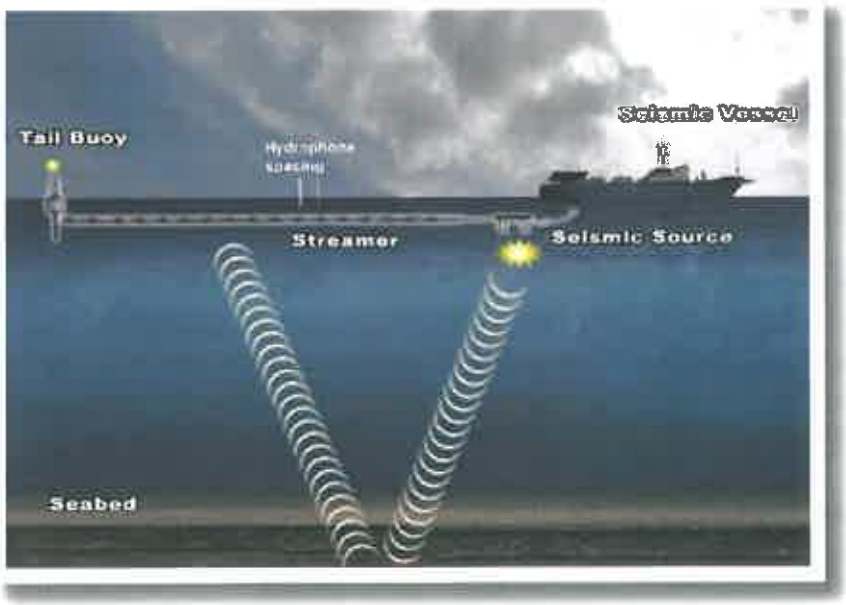
## Seismic survey – an ultrasound of the earth

Towards the end of 2013, Anadarko plans to conduct a two–dimensional (2-D) seismic survey in the Pegasus Basin.

Seismic surveying is a technique used by geoscientists to map geological formations beneath the earth's surface. It is an integral step in the process to determine whether oil or natural gas may be present and available for development.

The seismic survey will be conducted using a specially equipped vessel, towing behind it a streamer of hydrophones (listening devices) up to 10km in length. The vessel sends sound waves towards the sea floor and the hydrophones measure the reflected energy. Like an ultrasound of the earth, this process creates computer-generated images of structures beneath the surface.

Depending on the results of the 2-D survey, Anadarko may opt to conduct a more detailed 3-D seismic survey in the future. A 3-D survey would determine the feasibility of drilling an exploratory well which, if it were to go ahead, would happen around 2017.




## Environmental Protection

Anadarko is a signatory to the New Zealand Department of Conservation's Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations (http://www.doc.govt.nz/Documents/conservation/native-animals/marine-mammals/seismic-survey-code-of-conduct.pdf). The code is designed to ensure that marine mammals are protected during seismic acquisition.

The code requires survey vessels to have, at a minimum, two trained Marine Mammal Observers onboard. If an observer, or any other member of the crew, identifies a mammal within one kilometer of the vessel operations will stop until the animal has passed. If a calf is sighted, this distance increases to 1.5 kilometers.

To support the observers, a Passive Acoustic Monitoring (PAM) system is used to detect any noise from whales or dolphins. This also ensures that these animals do not go undetected at night. Two PAM operators are aboard the vessel at all times during operations.

To learn more about Anadarko, visit www.anadarko.com

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Terry Bentley

Environmental Manager

Anadarko

11th December 2013

Tēnā koe Terry

**Te Rūnanga o Kaikōura response to Seismic Survey**

Following on from our meeting at Takahanga marae earlier in the year, we provide this response to inform your assessment of the impacts of seismic surveying off the Kaikōura coast on Ngāti Kurī.

We understand that the Marine Mammal Impact Assessment (MMIA) has not yet been provided to the Department of Conservation (DOC) for the seismic survey planned for this summer. We request that our concerns, and proposals to address those concerns, should inform that assessment and result in additional conditions around the activity.

We have previously described to you the deep and abiding relationship that Ngāti Kurī have with the Kaikōura whales, connected through whakapapa, as well as the importance of marine mammals to the Kaikōura community as a whole. When you read this response, we ask that you think of what we have shared with you around kaitiakitanga, and what this activity represents from our perspective.

Our concerns and recommendations are as follows:

*Concern*

- There has been no detailed conversation since the last meeting at Takahanga and Ngāti Kurī have not had access to material associated with the planned seismic survey.

*Recommendations*

- Share the contents of the MMIA ahead of lodging with DOC and the EPA and enable Ngāti Kurī to provide feedback around the assessment, to further inform the assessment from the iwi perspective.

*Concern*

- There are times when the risks are greater for certain marine mammal species, so it may be possible to avoid additional risk through careful timing of the survey.

*Recommendations*

- Ensure that the survey does not occur during a period of known whale migration, or during calving.

*Concern*

- We do not have experience of seismic surveys and are reliant on reassurances provided by DOC and industry that protection provided by the rules in the Code of Conduct are sufficient to ensure no adverse impacts on marine mammals.

*Recommendations*

- Provided there is capacity on the seismic survey vessel for at least one cultural observer, that at least one member of Ngāti Kurī is on-board during the operation.
- Enable communication between the seismic survey vessel and Whale Watch Kaikōura during the operation, to share observations of whale behavior and the results of monitoring by MMOs on the seismic survey vessel.
- Provide all monitoring results of the MMOs to Ngāti Kurī at the end of the survey operation, as well as details of the operation sufficient to demonstrate compliance with the DOC Code of Conduct.
- Ensure that any dead or beached whales that appear during the period of testing, which could have been carried by Pegasus Basin currents, are autopsied to determine if they have physiological damage that could be attributed to survey activities.
- Ensure that Anadarko work with DOC and Ngāti Kurī to develop an on-going programme of research within the Pegasus Basin, looking at measurable impacts of seismic surveys on marine mammals and other marine species present in the Hikurangi Trench and surrounds. This recommendation is made on the understanding that there will be more surveys of the Basin in coming years, which Anadarko is likely to be involved with, along with other companies interested in the resources of the Basin, so it is important that work is undertaken to better understand the site specific impacts.

*Concern*

- There is risk to Ngāti Kurī and to the Kaikōura economy from planned activity, and little obvious benefit.

*Recommendations*

- Provide Ngāti Kurī and Te Korowai o Te Tai o Marokura with the results of seafloor mapping and associated information that could inform wider research into the Hikurangi Trench and surrounds.
- Provide funding for a member of Ngāti Kurī and a member of the wider Kaikōura community to train as Marine Mammal Observers (MMOs).

- Provide funding for Ngāti Kurī to participate in processes and provide a cultural impact assessment in order to inform decision-making around the range of activities that will be undertaken during exploration.

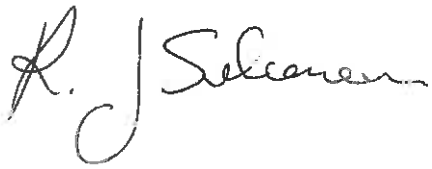
*Concern*

- The results of the seismic survey may result in future exploratory drilling within the Pegasus Basin.

*Recommendations*

- Ensure that there is on-going and improved communication with Ngāti Kurī, in terms of timing and content, around planned activities, so that there is time for hapū members to inform the process outside of statutory timeframes and build understanding.

Nāhaku noa, nā



Raewyn Solomon

Environmental Coordinator

Te Rūnanga o Kaikōura

CC: Alan Seay

Dave Lundquist

***FULL LIST OF CONSULTED PARTIES***

*Iwi and Hapu Groups*

Ngati Kuri
Ngai Tahu
Rangitane o Wairarapa
Te Runanga a Rangitane o Wairau Trust
Te Atiawa ki te Upoko o te Ika a Maui Potiki Trust
Ngati Toa Rangitira
Ngati Kuia
Ngati Koata Trust
Port Nicholson Block Settlement Trust
Ngati Kahungungu

*Local Government*

Greater Wellington Regional Council
Wellington City Council
Hutt City Council
South Wairarapa Council
Carterton Council
Masterton Council
Marlborough District Council
Kaikoura District Council

*Local MPs*

MP for Kaikoura
MP for Wellington Central
MP for Hutt South
Green Party Kaikoura representative
MP for Wairarapa
Rino Tirakatene, MP for Te Tai Tonga
Meka Whaitiri, MP for Ikaroa-Raawhiti

*Business Interests*

Whale Watch Kaikoura
Kaikoura i-site
Kaikoura Dolphin Encounter

Te Korowai

Marlborough Chamber of Commerce

Wellington Chamber of Commerce

*Fishing Interests*

Seafood industry Council

Deepwater Group, Seafood New Zealand

Te Ohu Kaimoana

Independent Fisheries

Annex B

# Sound Transmission Loss Modeling Report

## *B1 INTRODUCTION*

This *Annex* describes the methodology, assumptions and data sources used in the underwater noise modelling study. It also provides a description of the results that have been obtained.

## B2 NOISE SOURCE

### B2.1 ACOUSTICS SOURCES

The modelled seismic array pressure outputs have been provided by GardlineCGG and are compatible with other sources of information for air guns with similar characteristics. The source term is based on an emission not exceeding approximately 259 dB re 1 µPa at 1m (peak to peak) or 253 dB re 1 µPa at 1m (Peak).

The frequencies and directionality of the seismic source are determined by the exact configuration of the seismic series. In this case, the exact configuration is not determined, although it is assumed that a seismic array with a total volume of 3610 $in^3$ will be used. The tow depth of the array is likely to be 12 m.

### B2.2 DIRECTIVITY

The directional nature of these sources is discussed in OSPAR [1]. The document states that generated seismic air gun pulses at low frequencies (below 250 Hz) with higher energies in the range of 10-120 Hz and peaks between 30 and 50 Hz also release sounds of low amplitude at high frequencies, having measured a value of acoustic energy around 100 kHz (Deruiter et al. 2006 [2]; Goold & Coates 2006 [3], Bain & Williams 2006 [4] Sodal 1999 [5] and Madsen et al. 2006 [6]). While the energy at the frequency of interest (10 to 120 Hz) is radiated primarily downwards, some sound energy is also radiated in horizontal directions. Other research seen at Wyatt for Joint Industry Programme (JIP ) [7] referenced studies showing that 90% of their energy is in the range of 70 to 140 Hz (van de Sman 1998) [8]. The modelling data which has been supplied for the airgun source shows that noise levels are highest on-axis directly below the vessel, and that noise levels at other locations would be lower.

The air guns are fired in series to generate a pulse of low frequency energy along the seabed. However, it is likely for them to form other energy pulses in various directions depending on the frequency, at up to 100 kHz. In the propagation model it has been assumed that the source behaves as a single

(1) Overview of the impacts of anthropogenic underwater sound in the marine environment, OSPAR, 2009.
(2) DeRuiter, S.L.; Tyack, P.; Lin, Y.-T.; Newhall, A.E.; Lynch, J. & Miller, P.J.O. 2006: Modeling acoustic propagation of airgun array pulses recorded on tagged sperm whales. IWCSC/58/ForInformation1.
(3) Goold, J.C. & Coates, R.F.W. 2006: Near Source, High Frequency Air-Gun Signatures. IWCSC/58/E30.
(4) Bain, D.E. & Williams, R. 2006: Long-range effects of airgun noise on marine mammals: Responses as a function of received sound level and distance. IWC-SC/58E35.
(5) Sodal, A. 1999: Measured underwater acoustic wave propagation from a seismic source. In: Proceedings of the Airgun Environmental Workshop, London, July 6, 1999.
(6) Madsen, P.T., Johnson, M, Miller, P.J.O., Aguilar Soto, N., Lynch, J. & Tyack, P. 2006b: Quantitative measures of airgun pulses recorded on sperm whales (Physeter macrocephalus)
(7) Joint Industry Programme on Sound and Marine Life Review of Existing Data on Underwater Sounds Produced by the Oil and Gas Industry Issue 1, Wyatt, 2008.
(8) Van de Sman, P. M. (1998). Environmental Aspects of Air Guns, Shell EXPRO: 25, 1998.

point source that radiates in all directions in the same way. Since the seismic array's directional characteristics have not yet been determined at this stage of the project, a worst case approach has been adopted. Based on the form of the data that was supplied for directivity corrections, a worst case scenario is obtained by not subtracting any of the directivity correction from the peak source level.

### B2.3 *SOURCE FREQUENCY BANDS*

The estimated levels for a seismic air gun source of 3,090 $in^3$ were suggested by Thompson [1] after a series of reviews of several studies of the geometry of the seismic spectrum from various sources. The results of his research are presented in *Table 2.1.*

*Table 2.1* ***Thompson's Spectral Estimation for a 3,090$in^3$ Air Gun***

| Frequency (Hz) | Spectral Level Thompson (dB re $\mu Pa^2.Hz^{-1}$) |
|---|---|
| 10 | 208 |
| 20 | 211 |
| 50 | 212 |
| 100 | 211 |
| 200 | 190 |
| 500 | 180 |
| 1000 | 166 |
| 2000 | 145 |
| 5000 | 140 |
| 10000 | 130 |
| 20000 | 124 |

The Thompson spectrum presents high levels for low frequency noise compared to higher frequency. As mentioned above, the source term for this project is a source level not exceeding approximately 259 dB re 1 µPa at 1m (Peak to Peak) or 253 dB re 1 µPa at 1m (Peak) [2]. Note that this source level is derived assuming that all noise is emitted from a single source location. In reality an array of air guns will form a distributed noise source and noise levels near individual air guns will be lower than modelled.

Sound pressure referred to above may be expressed either as Peak to Peak, Peak, Root Mean Square (Root Mean Square - RMS). These values are measured over the duration of one pulse from an air gun. The RMS value for the pulse given by an air gun is usually about 10 dB lower than the Peak level , and about 16 dB less than the Peak -to -Peak value (Greene , 1997, McCauley and others , 1998 , 2000a) [3] [1] [2].

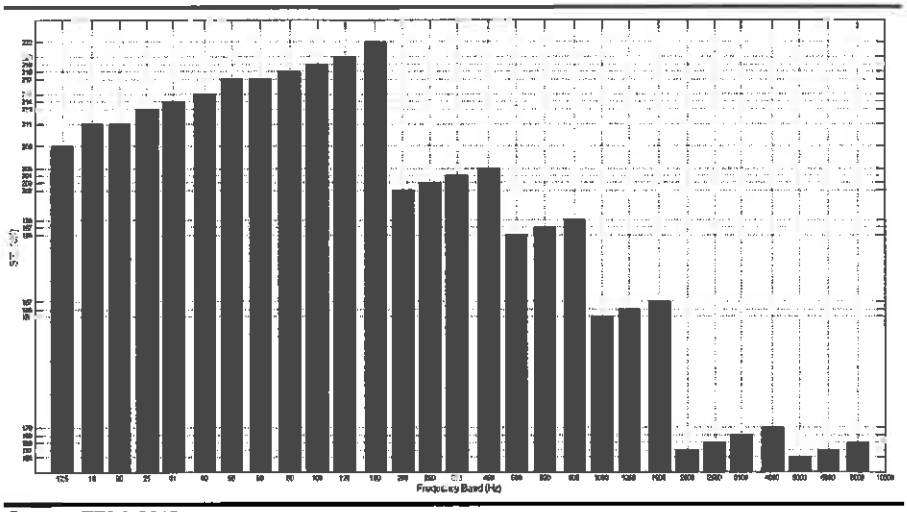
(1) Underwater noise propagation modelling and estimate of impact zones for seismic operations in the Moray Firth, P. Thompson for Kongsburg Maritime, 2010.

(2) Data were provided for modelled peak pressure for 6 m and 10 m tow depths. These values showed negligible variation and therefore the 10 m tow depth modelling has been assumed to be sufficiently accurate to establish the source term for this project.

(3) Greene, C.R., Jr. 1997. Physical acoustics measurements. p. 3-1 to 3-63 In: W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2.

The Sound Exposure Level is the effective total energy level a subject is exposed to over the normalised duration of one second. Since an airgun single pulse lasts about 1/10 of a second it can be shown that SEL of the pulse is about 10 dB lower than its RMS level. Based on this knowledge in combination with Thompson's spectral estimation presented above, a one third octave RMS spectrum was derived which was then calibrated to meet the expected RMS source term, 243 dB re 1 µPa RMS, for an airgun array of 3610 $in^3$. This was then used to derive the SEL spectrum which was adopted for the source. That spectrum is presented in *Figure 2.1*.

*Figure 2.1* ***SEL Source Spectrum based on Thompson's Spectral Estimation***



Source: ERM; 2013

As the propagation of underwater noise is frequency dependent, modelling of attenuation and source levels has been carried out at the centre frequencies of the one-third octave bands.

(1) McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental expo sures. APPEA J. 38:692-707.
(2) McCauley and others , 2000a

## B3 NOISE PROPAGATION

### B3.1 PROPAGATION MODELLING SOFTWARE

The underwater noise propagation has been modelled using the spreading model known as RAMGEO, version 2.21 ACTUP [1]. The modelling took into account the following factors:

- bathymetry;
- sound velocity profiles in a water column and sediment;
- frequency of sound, and
- absorption and reflection at the seabed interface and the water surface.

The modelling was performed for two key transects which are expected to represent the worst case scenarios for underwater sound propagation at the specific site.

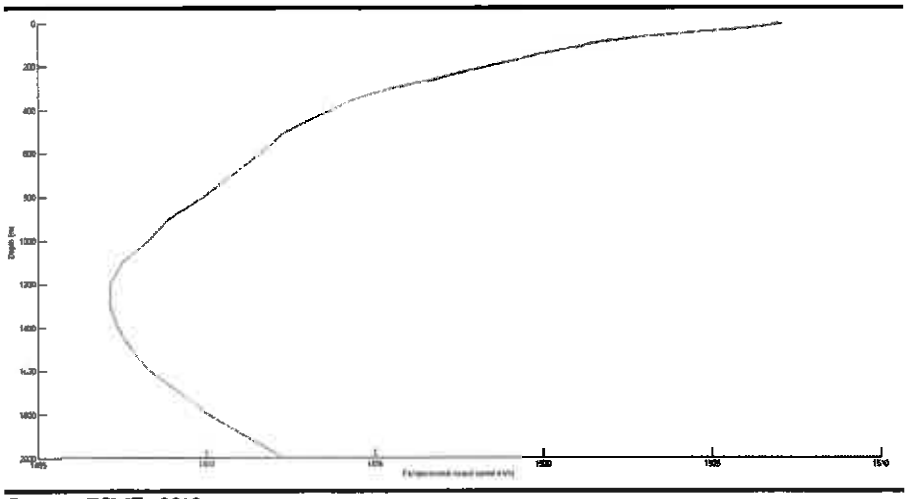
### B3.2 ASSUMPTIONS FOR THE WATER COLUMN

The sound speed profiles for the water column are based on those provided by Anadarko that were taken in the study area during May 2013. Data for a profile about 2000 m deep are available for the time at which the seismic acquisition survey is planned to be conducted (in January). Other profiles have been reviewed from the U.S. Naval Oceanographic Office's Generalized Digital Environmental Model (GDEM) database. The GDEM database (version 3.0) provides average monthly profiles of temperature and salinity for oceans on a latitude-longitude grid with 0.25° resolution, based on global historical observations from the U.S. Navy's Master Oceanographic Observation Data Set (MOODS).

These GDEM data have been used to calculate sound speed profiles in the ESME noise modelling software that has been produced by Boston University for the Office of Naval Research (ONR) and sound speed profiles produced in this way have been compared during the data provided by Anadarko for a comparable autumn month and found to give good agreement. Sound speed profiles November to January have then been compared and have been reviewed to obtain values of the sound velocity for various depths. The sound velocities showed good agreement especially at low depths for all seasons. The sound velocity profile assumed for this study is shown in *Figure 3.1*.

(1) Acoustic Toolbox User interface and Post processor, CMST (Curtin University).

*Figure 3.1* ***Sound Speed Profile Adopted for the Modelling***



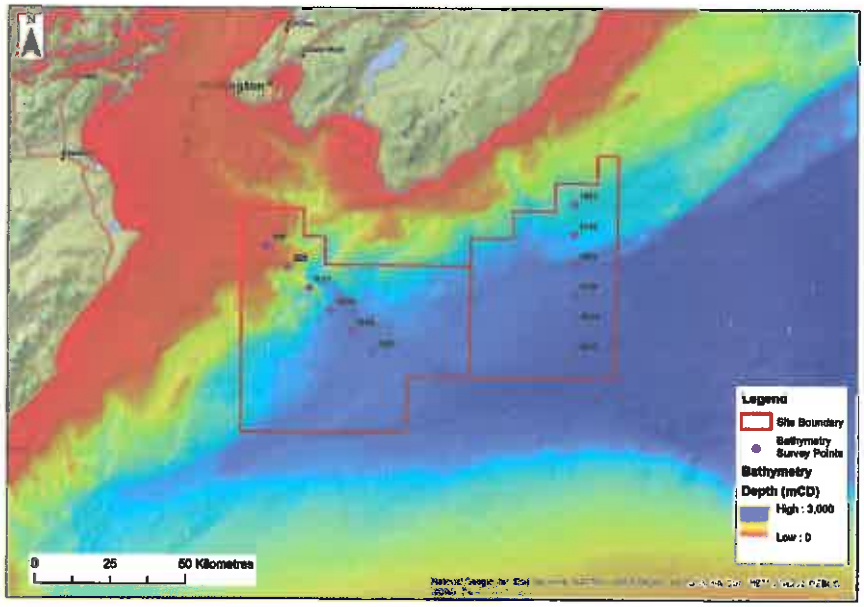
Source : ESME , 2013

*B3.3* *ASSUMPTIONS FOR BATHYMETRY AND SEDIMENTS*

Files of detailed bathymetry of the study area were imported into a GIS surface model and depths were extracted along the propagation transects and input to the model. The deepest parts of the survey areas are approximately 2700 m while depths in coastal areas reduce to approximately 100 m. Two key transects have been selected to indicate the effect of bathymetry profiles which are expected to give maximum potential noise levels.

A relatively shallow vessel location was assumed for one analysis. This situation is depicted in "Transect 1" (in the Northwest of permit 54858). Another location, "Transect 2", was chosen to show the extent of the impact of noise in deeper water. These two locations are presented in *Figure* 3.2.

*Figure 3.2* ***Bathymetry Map of Survey Area***




Source : ERM , 2013

The survey area is located on the northern edge of the Pegasus basin at the southern end of Cook Strait. The north-western corner of area 54858 and the northern margins of 54861 include areas of the continental shelf (such as the Campbell Bank in the northwest) and continental slope down into the Pegasus basin, deeply incised by a network of submarine canyons (such as the Nicholson Canyon in the north) that link to the axial east-flowing Hikurangi Canyon.

These canyons are formed by erosion from turbidity currents initiated by submarine landslips on the shelf and slope, frequently triggered by tectonic activity. The turbidity currents comprise rapidly moving, dense, suspended clouds of mixed sands, silts and clays that flow axially in canyons up to 100 km eastward through the Pegasus basin, with suspended material frequently escaping the canyons en-route to settle around the canyons and across the wider basin floor. Thus sea-bed sediments in the basin are mainly clays and silts dropped out of suspension from passing turbidity currents and from pelagic clay. Sea-bed sediments on the shelf are dominated by sands (e.g. medium to coarse sand on the Campbell Bank). The characteristics of the seabed sediment were based on available public data [1] , and the seabed was modelled as a 200 m deep sediment layer over a highly absorptive half-space. (A half space is effectively an infinite region with a single property. Energy transmitted into this region does not return to the water column.)

(1)Chris Uruski & Craig Jones, 2007. Preliminary desktop study of available marine and geophysical data in the Pegasus Sub-basin, East Coast, North Island. PR3919, Ministry of Economic Development,

The assumptions made are shown in *Table 3.1.*

*Table 3.1* ***Acoustic Parameters for Sea-bed and Half-space***

| | Depth (m) | Density ($kgm^{-3}$) | Sound Velocity(m/s) | Absorption (dB/λ) |
|---|---|---|---|---|
| Silty Clay Sea-bed Sediment | 200 | 1300 | 1485-1700 (increasing with distance after first 50m) | 0.1-10 (increasing with distance after first 50m) |
| Half-space | infinite | 1300 | 1700 | 10 |

## B4 RESULTS OF THE MODELLING

### B4.1 SCREENING ASSESSMENT FOR ALL SPECIES

The noise modelling in this area has been carried out taking into account site specific factors that are required to predict the propagation of noise. The sound velocity in the water is likely to decreases relatively rapidly in the first few kilometres out from the source, and this leads to sound waves being refracted downwards into the silty-clay sea bed material where they are effectively absorbed. The relatively shallow depths also ensure the waves do not travel far horizontally before reaching the sea bed.

The NZ guidance (1) sets out the requirements for detailed modelling such as has been carried out for this project and it states that:

*"The results of such modelling should give an indication of the relative distances from the acoustic source over which 171 dB re 1 µPa²-s SEL (behaviour criteria) and 186 dB re 1 µPa²-s SEL (injury criteria) could be expected. Depending on the outcomes, if these levels are predicted to occur at greater distances than the relevant mitigation zones (Species of Concern with calves and Other Marine Mammals respectively), then additional mitigation measures such as just described must be discussed with the Department and considered for implementation."*

These criteria have been confirmed as M-weighted values (for low, medium and high frequency cetaceans and pinnipeds as defined in Southall et al(2)). This is a stringent assessment because the values in the guidance are for the most sensitive group of species (i.e. pinnipeds in water). Effectively, the guidance applies a precautionary screening approach. If levels are below the pinniped criteria then no further discussion is required and standard mitigation zones will be applied. If levels are above the criterion then it would be necessary to compare the M-weighted value for each hearing group with the corresponding criterion to determine if an impact will exist and further mitigation is justified following the guidance on which the NZ guidance is based.

The results for Transect 1 show that the noise will decay to below the screening criteria of *171 dB re 1 µPa²-s SEL (behaviour criteria)* at 400 m for high frequency cetaceans, 500 m for mid-frequency cetaceans, 1000 m for low-frequency cetaceans and 750 m for pinnipeds. The results also show that the *186 dB re 1 µPa²-s SEL (injury criteria)* would be met at <100 m for high frequency cetaceans, <100 m for mid-frequency cetaceans, 300 m for low-frequency cetaceans and 200 m for pinnipeds.

(1) 2012 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations, New Zealand Department of Conservation, 2012.
(2) Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas and P.L. Tyack. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals* 33(4):411-522.

The results for Transect 2 show that the noise will decay to below the screening criteria of *171 dB re 1 μPa²-s SEL (behaviour criteria)* at 400 m for high frequency cetaceans, 550 m for mid-frequency cetaceans, 1500 m for low-frequency cetaceans and 950 m for pinnipeds. The results also show that the *186 dB re 1 μPa²-s SEL (injury criteria)* would be met at <100 m for high frequency cetaceans, <100 m for mid-frequency cetaceans, 300 m for low-frequency cetaceans and 200 m for pinnipeds.

The results of the screening assessment show that all species comply with the screening criteria except for low frequency cetaceans. Therefore, further specific assessment results for low-frequency cetaceans (according to Southall et al[1]) are described in the *Section B4.3* whilst the results of the screening assessment described above for all other species are described in *Section B4.2*.

## B4.2 *PINNIPEDS, MID-FREQUENCY CETACEANS AND HIGH-FREQUENCY CETACEANS*

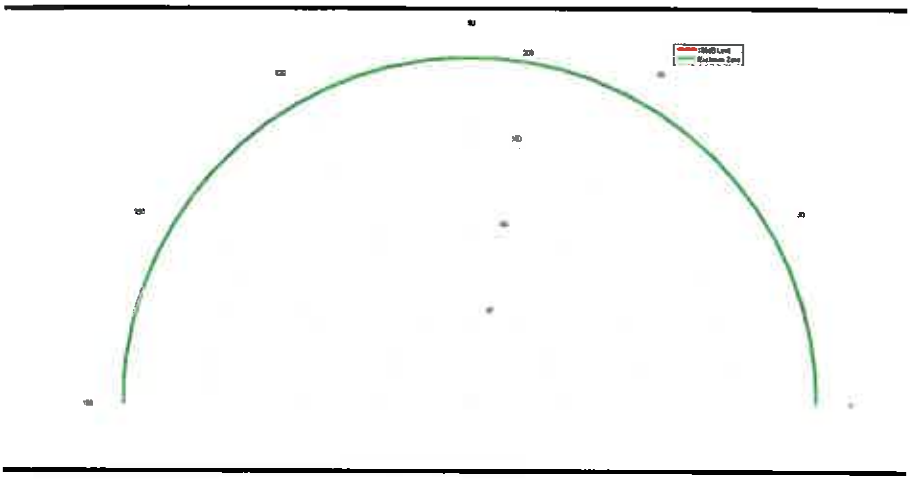
The results are presented graphically below for the screening assessment described in the NZ guidance for mid-frequency and high frequency cetaceans and pinnipeds in water. The predicted noise levels vary as a result of the different frequency weighting values that are applied to the different hearing groups, but the results are plotted using the pinniped results which were found to be the most likely to exceed the screening limit in the guidance for this grouping.

All of the results are based on the modelled noise propagation transect in this report the labelled plot angles are not intended to indicate the direction of the modelled transect. The figures are based on the worst-case propagation situation in any direction and do not include reductions due to directivity.

The results for Transect 1 are shown graphically in *Box 4.1* and *Box 4.2* for Pinnipeds (which results in the largest range *Box 4.1* for the 186 dB *re 1 μPa²-s SEL* limit and *Box 4.2* for the 171 dB *re 1 μPa²-s SEL* limit.

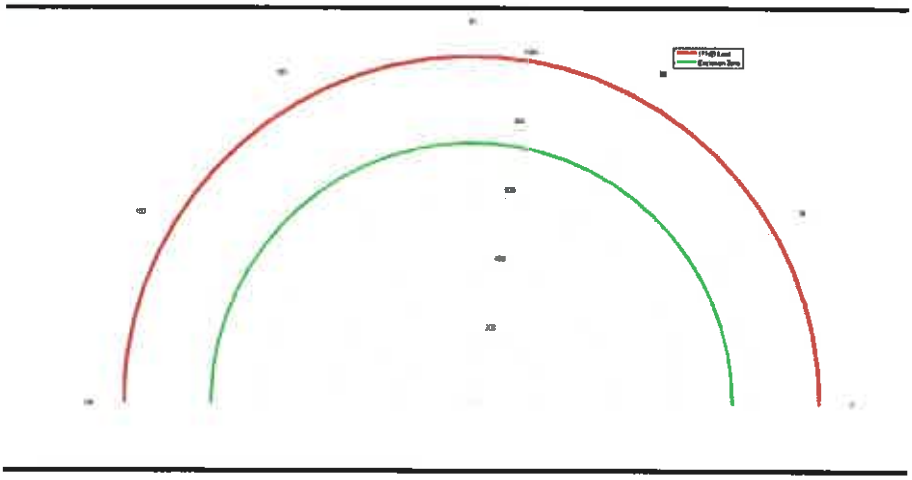
(1) Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas and P.L. Tyack. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals* 33(4):411-522.

*Box 4.1* ***Figure Showing Extent of 186 dB re 1 µPa²-s SEL for Pinnipeds (Injury Criterion) - Transect 1***



The predicted noise levels are below the 186 dB *re 1 µPa²-s SEL* limit at all depths at 200 m from the source.

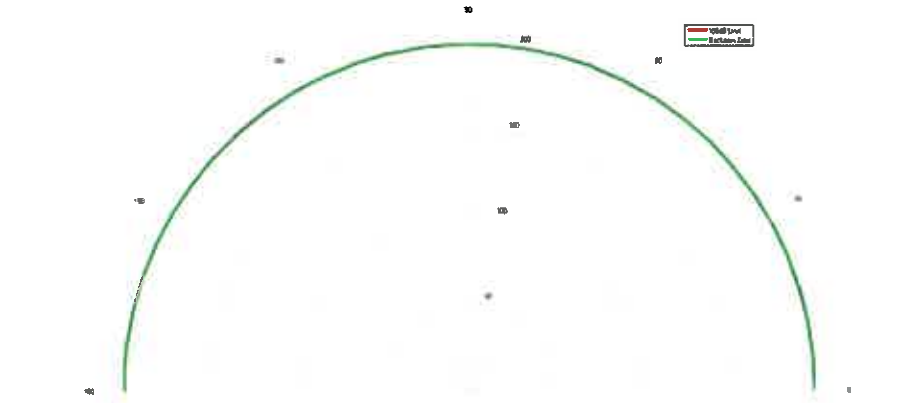
*Box 4.2* ***Figure Showing Extent of 171 dB Limit 171 dB re 1 µPa²-s SEL for Pinnipeds (Behaviour Criterion) - Transect 1***



The predicted noise levels are below the 171 dB *re 1 µPa²-s SEL* limit at all depths at 1000 m from the source.

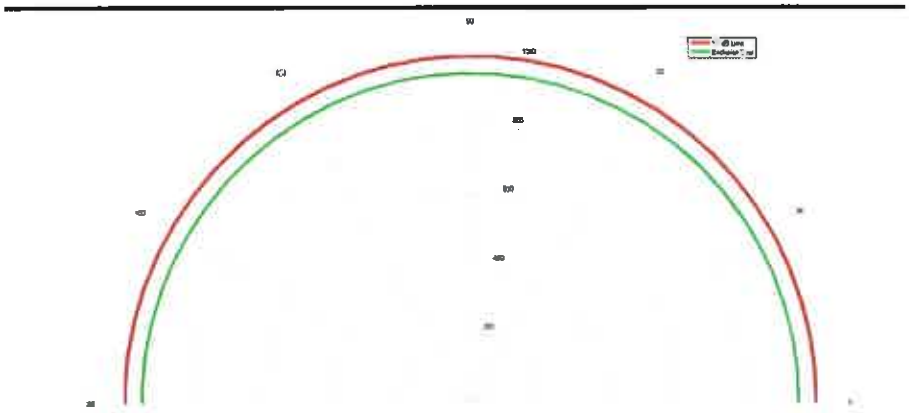
The results for Transect 2 are shown graphically in *Box 4.3* and *Box 4.4* for pinnipeds (which results in the largest range of impact) *Box 4.3* for the 186 dB *re 1 µPa²-s SEL* limit and *Box 4.4* for the 171 dB *re 1 µPa²-s SEL* limit.

*Box 4.3* ***Figure Showing Extent of 186 dB re 1 µPa²-s SEL for Pinnipeds (Injury Criterion) - Transect 2***



The predicted noise levels are below the 186 dB *re 1 µPa²-s SEL* limit at all depths at 200 m from the source.

*Box 4.4* ***Figure Showing Extent of 171 dB Limit 171 dB re 1 µPa²-s SEL for Pinnipeds (Behaviour Criterion) - Transect 2***



The predicted noise levels are below the 171 dB *re 1 µPa²-s SEL* limit at all depths at 1000 m from the source.

*B4.3* *LOW-FREQUENCY CETACEAN RESULTS*

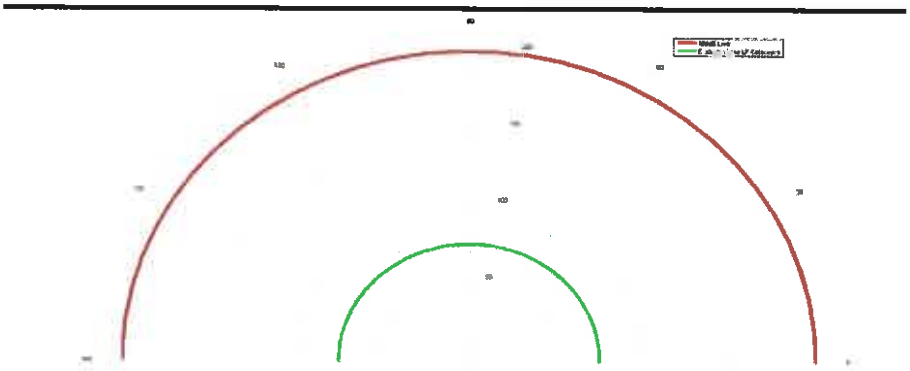
In order to investigate if further mitigation may be required to protect low-frequency cetaceans the assessment specified in Southall et al[1] has been applied, and the M-weighted predicted noise levels for low frequency cetaceans are compared with the relevant criteria which are 183 dB re 1 µPa²-s SEL (behaviour criteria) and 198 dB re 1 µPa²-s SEL (injury criteria).

(1) Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas and P.L. Tyack. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals* 33(4):411-522.

The predicted levels were found to meet the appropriate limits at 400 m (behaviour criteria) and <100 m (injury criteria). Therefore, the mitigation zones of 1000 m and 200 m specified in the NZ guidance are sufficient to avoid a significant noise impact (based on the single pulse criteria that are used elsewhere in the guidance), and further mitigation is not justified based on the results of this assessment.

The results for Transect 2 (the worst case) are shown graphically for Low-frequency cetaceans in *Box 4.5* for the 198 dB *re 1 µPa²-s SEL* limit and in *Box 4.6* for the 183 dB *re 1 µPa²-s SEL* limit.

*Box 4.5* ***Figure Showing Extent of 198 dB re 1 µPa²-s SEL Limit for Low-frequency Cetaceans (Injury Criterion) - Transect 2***



The predicted noise levels are below the 198 dB *re 1 µPa²-s SEL* limit at all depths at 200 m from the source.

*Box 4.6* ***Figure Showing Extent of 183 dB re 1 µPa²-s SEL Limit for Low-frequency Cetaceans (Behaviour Criterion) - Transect 2***

The predicted noise levels are below the 183 dB *re 1 µPa²-s SEL* limit at all depths at 1000 m from the source.

Annex C

# Details of Passive Acoustic Monitoring System

## Gardline Environmental Ltd

## Passive Acoustic Monitoring System Specifications

## *MV Duke*

| | | |
|---|---|---|
| *General* | | |
| Manufacturer | Seiche Measurements Ltd | Seiche Measurements Ltd |
| Model | 511-100 m | 511-10 m |
| *Towed streamer section* | | |
| Length | 100 m | 10 m |
| Section diameter | 14mm over cable, 32mm over mouldings | 14mm over cable, 32mm over mouldings |
| Number of Hydrophones | 4 | 4 |
| Hydrophone type | Custom built by Seiche Measurements<br>4 broadband | Custom built by Seiche Measurements<br>1 low frequency,<br>3 broadband |
| Receive sensitivity (dB re 1 V/µPa) | -166 | -166 broadband<br>-157 low |
| Hydrophone separation | Hydrophone 1 and 2 1.2 m<br>Hydrophone 2 and 3 90 m<br>Hydrophone 3 and 4 1.2 m | Hydrophone 1 and 2 0.25 m<br>Hydrophone 2 and 3 1.2 m<br>Hydrophone 3 and 4 1.2 m |
| Preamplifiers | 4 broadband | 1 low frequency, 3 broad band |
| Preamplifier type | Custom built by Seiche Measurements Ltd. | Custom built by Seiche Measurements Ltd. |
| Depth sensor manufacturer | Keller | Keller |
| *Tow cable* | | |
| Length | 230 m | 230 m |
| Diameter | 17 mm | 17 mm |
| Termination | 19 pin Seiche Connectors | 19 pin Seiche Connectors |
| *Deck cable* | | |
| Length | 100 m | 100 m |
| Diameter | 14 mm | 14 mm |
| Termination | 19 pin ITT Connectors | 19 pin ITT Connectors |

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