Vertical Seismic Profiling Canterbury Basin (PEP 38264) New Zealand

Marine Mammal Impact Assessment and Marine Mammal Management Plan

Anadarko New Zealand Company

March 2014

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FINAL REPORT

Anadarko New Zealand Company

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CONTENTS

1	INTRODUCTION	
1.1	BACKGROUND	1
1.2	THE APPLICANT	1
1.3	LOCATION AND TIMING	1
1.4	CONSULTED SOURCES OF INFORMATION	2
1.5	CONSULTATION	3
1.6	LIMITATIONS	5
2	ADMINISTRATIVE FRAMEWORK	
2.1	NATIONAL LEGISLATION	6
2.1.1	THE EEZ ACT	6
2.1.2	THE CODE	7
2.2	INTERNATIONAL CONVENTIONS, TREATIES, AGREEMENTS AND PROGRAMS	8
2.2.1	INTERNATIONAL REGULATIONS FOR THE PREVENTION OF COLLISIONS AT SEA, 1972	8
2.2.2	INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973 AS MODIFIED BY THE PROTOCOL OF 1978	8
2.2.3	UNITED NATIONS CONVENTION ON THE LAW OF THE SEA, 1982	8
2.2.4	CONVENTION ON BIOLOGICAL DIVERSITY, 1992	8
3	PROJECT DESCRIPTION	
3.1	OVERVIEW	9
3.2	VERTICAL SEISMIC PROFILING	9
3.2.1	EQUIPMENT	9
3.2.2	DATA ACQUISITION	11
3.2.3	TIME ESTIMATE	12
3.3	ENVIRONMENTAL CONSIDERATIONS	12
3.3.1	SOFT START PROCEDURES	12
3.4	SAFETY CONSIDERATIONS	13
4	EXISTING ENVIRONMENT	
4.1	BIOLOGICAL ENVIRONMENT	14
4.1.1	BENTHIC COMMUNITIES	14
4.1.2	COLDWATER CORALS	15
4.1.3	FISH COMMUNITIES	16
4.1.4	MARINE MAMMALS	23
4.1.5	MARINE REPTILES	36
4.1.6	PROTECTED NATURAL AREAS IN THE VICINITY OF THE PROJECT AREA	36
4.2	EXISTING INTERESTS	39
4.2.1	GENERAL DEMOGRAPHICS	39
4.2.2	MARITIME TRAFFIC, PORTS AND HARBOURS	41
4.2.3	FISHING	42
4.2.4	OIL AND GAS ACTIVITY	43

4.2.5	MUNITIONS DUMP	43
4.2.6	TOURISM	44
4.2.7	OTHER USES	44
4.2.8	CULTURAL ENVIRONMENT	44
5	IMPACT ASSESSMENT METHODOLOGY	
5.1	ASSESSMENT METHODOLOGY STAGE I: IDENTIFICATION OF POTENTIAL IMPACTS AND SCOPING	46
5.2	ASSESSMENT METHODOLOGY STAGE II: DEVELOPING MITIGATION MEASURES	48
5.3	ASSESSMENT METHODOLOGY STAGE III: EVALUATING RESIDUAL IMPACTS	49
5.4	ASSESSMENT METHODOLOGY STAGE IV: RE-EVALUATING SIGNIFICANT RESIDUAL IMPACTS	54
5.5	EVALUATION CRITERIA FOR ACCIDENTAL OR UNPLANNED EVENTS	54
5.6	EVALUATION CRITERIA FOR ACCIDENTAL OR UNPLANNED EVENTS	55
5.7	DEALING WITH UNCERTAINTY IN THE ASSESSMENT OF IMPACTS	55
6	VERTICAL SEISMIC PROFILING IMPACT ASSESSMENT	
6.1	INTRODUCTION	56
6.2	IMPACT ASSESSMENT SCOPE	56
6.3	SOURCE SOUND EMISSIONS	57
6.3.1	PHYSIOLOGICAL EFFECTS ON MARINE FAUNA FROM EXPOSURE TO NOISE OR ASSOCIATED PRESSURE EFFECTS	60
6.3.2	BEHAVIORAL DISTURBANCE LEADING TO BEHAVIORAL CHANGES OR DISPLACEMENT	63
6.3.3	INTERFERENCE WITH THE USE OF ACOUSTIC COMMUNICATION SIGNALS, OR NATURALLY-PRODUCED CUES USED BY MARINE ANIMALS	65
6.3.4	DISRUPTION TO FEEDING, SPAWNING AND CALVING ACTIVITIES OF MARINE FAUNA	69
7	MARINE MAMMAL MANAGEMENT PLAN AND THE 2013 CODE MANAGEMENT MEASURES	
7.1	LEVEL ONE SURVEY REQUIREMENTS	74
7.1.1	PRE-SURVEY PLANNING	74
7.1.2	OBSERVER REQUIREMENTS	74
7.1.3	PRE-START OBSERVATIONS	75
7.1.4	DELAYED STARTS AND SHUTDOWNS	76
7.1.5	COMMUNICATIONS FLOW	77
7.2	MARINE MAMMAL OBSERVER AND PASSIVE ACOUSTIC MONITOR OPERATOR TRAINING AND EXPERIENCE	78
7.3	OPERATIONAL DETAILED REQUIREMENTS	79
7.3.1	OBSERVER EFFORT	79

CONTENTS

7.3.2	*MARINE MAMMAL OBSERVER DUTIES*	*80*
7.3.3	*PASSIVE ACOUSTIC MONITOR OPERATOR DUTIES*	*80*
7.3.4	*AUTHORITY TO SHUT DOWN OR DELAY STARTS*	*81*
7.3.5	*OBSERVER DEPLOYMENT*	*82*
7.3.6	*CREW OBSERVATIONS*	*82*
7.3.7	*ACOUSTIC SOURCE POWER OUTPUT*	*82*
7.3.8	*SOFT STARTS*	*83*
7.3.9	*ACOUSTIC SOURCE TESTS*	*83*
7.3.10	*RECORDING AND REPORTING REQUIREMENTS*	*83*
7.3.11	*REPORT CONTENTS*	*84*
8	*LIST OF REFERENCES*	*87*

ANNEXURES

ANNEX A	*STAKEHOLDER ENGAGEMENT REGISTER*
ANNEX B	*PASSIVE ACOUSTIC MONITORING SYSTEM*

1 INTRODUCTION

1.1 BACKGROUND

This Marine Mammal Impact Assessment (**MMIA**) and Marine Mammal Management Plan (**MMMP**) have been prepared for Anadarko New Zealand Company (**Anadarko**) by Environmental Resources Management (**ERM**), a recognized independent international environmental consulting company.

Anadarko plans to undertake an oil and gas exploration/appraisal program located within the area of New Zealand (**NZ**) Petroleum Exploration Permit (**PEP**) Block 38264 of the Canterbury Basin, off the east coast of the South Island of NZ (hereafter "the Project Area"). During the drilling component of this program, which includes a single exploratory (Caravel) and potentially an appraisal well (Carrack), Anadarko will need to conduct detailed recording of the geologic formations penetrated by the borehole. To achieve this, Anadarko intends to undertake Vertical Seismic Profiling (**VSP**). The application of VSP across both Caravel and Carrack will hence forth be referred to as "the Project".

This MMIA and MMMP is specific to the Project, and will:

- Present the current understanding of the key environmental sensitivities and existing interests within the Project Area and surrounding environment as they relate to VSP;
- Assess the potential environmental impacts to the surrounding environment and existing interests as a result of VSP; and
- Present measures that will be implemented to avoid or minimize adverse impacts to the surrounding environment and existing interests.

1.2 THE APPLICANT

The Applicant is a joint venture comprising Anadarko (45%), Origin Energy Resources NZ Limited (45%), and Discover Exploration Limited (10%) with Anadarko being the operator.

1.3 LOCATION AND TIMING

The location of Caravel will be 171°30'9.96" E, 45°85'.07" S and Carrack will be 171°22'40.32" E, 45°50'58.35" S (*Figure 1.1*). Drilling in the Canterbury Basin was scheduled to begin in February 2014. It is estimated that the drilling activity will take approximately 45 to 60 days per well, of which VSP will be undertaken over approximately 5 to 6 hours per well. While it is expected VSP at Caravel will be undertaken between 6-15 March, the exact dates of VSP at the Carrick well cannot be estimated at this early stage.

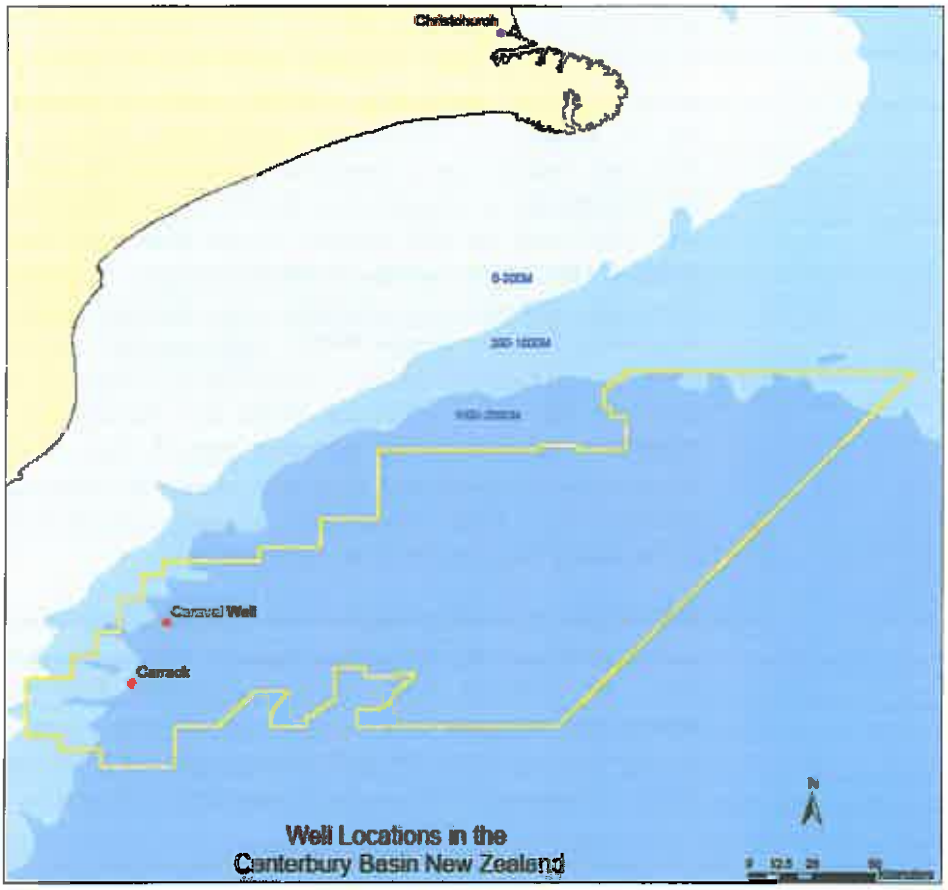


Figure 1.1 *Location of the Caravel and Carrack Wells*

1.4 CONSULTED SOURCES OF INFORMATION

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

- Oceanographic and climatological information were obtained from previous reports on the Canterbury Basin and data by the NZ National Institute of Water and Atmospheric Research Ltd (**NIWA**);

- Biological information was obtained from numerous sources. The general ecological and fisheries baselines were derived from selected species accounts, plenary documents, and other online information compiled by the NZ Ministry for Primary Industries (**MPI**, formerly the Ministry of Fisheries). Information on threatened species was obtained primarily from the Department of Conservation (**DOC**) *Threat Classification Lists* (DOC 2005, 2011) and the MPI *National Aquatic Biodiversity Information System* (**NABIS** MPI, 2013a) species distribution maps. Information on marine mammals, seabirds, and plankton was obtained from MPI and the Worldwide Fund for Nature (**WWF**), supplemented with information from the American Cetacean Society's online fact sheet database and information from the National Institute for Water and Atmospheric Research Ltd. (**NIWA**). 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, DOC and MPI; and

- Information on existing interests was obtained from several government and industry sources. 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). Economic data on fisheries were acquired from Statistics NZ and MPI.

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

1.5 CONSULTATION

The *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Activities* (the Code, DOC, 2013) 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; and

- Include copies of any written submissions from the consultation process.

In recognition of the stakeholder interest that could be generated by its proposed exploration drilling activities, Anadarko has initiated and undertaken a program of stakeholder engagement in order to inform relevant groups and individuals of its intended activities, including the planned VSP activities. The following key potential stakeholders have been identified as part of these engagement activities. Anadarko has an ongoing program of stakeholder engagement with these groups (see *Annex A* for a register of stakeholder meetings undertaken by Anadarko and *Section 4.2.8, Cultural Environment*, for further details regarding Anadarko's iwi engagement activities:

- Iwi and hapu groups: Māori tribal groups that are generally associated with a recognized territory (or rohe);
- Regional councils adjacent to the Project Area;
- Adjacent city and district councils;
- Local business interests;
- Local fishing interests;
- Ministry for the Environment;
- The Environmental Protection Authority (EPA);
- Maritime New Zealand (Maritime NZ);
- DOC;
- The NZ Minister of Energy & Natural Resources;
- NZ Petroleum and Minerals;
- The NZ Ministry of Business, Innovation and Employment, including the former NZ Ministry of Economic Development and NZ Department of Labour; and

Local non-governmental organizations that have an expressed interest in the project. No specific concerns or issues regarding the associated drilling program (including the planned VSP activities) were raised as part of Anadarko's formal consultation program outlined in Annex A. Anadarko has also had a number of interactions with Maori media to ensure information reaches a wider iwi audience than those attending meetings. A Cultural Impact Assessment (**CIA**) is being prepared on behalf of the iwi for the project activities. The purpose of the CIA is to provide an analysis of the cultural and socio-economic potential adverse effects of the project activities on the people, lands, waters and wider environment of iwi.

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 MMIA and MMMP were prepared on the basis of published information in existence at the time of report issuance (March 2014) that could be readily obtained from relevant 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.

2 ADMINISTRATIVE FRAMEWORK

2.1 NATIONAL LEGISLATION

National legislation applicable to the offshore oil & 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**);
- *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
- *2013 Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Activities* (**the Code**).

2.1.1 *The EEZ Act*

The primary piece of national legislation that seeks to manage the environmental impacts of activities such as oil and gas exploration in this area is the EEZ Act. 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 *Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Regulations 2013* (**the Regulations**) were promulgated. These regulations prescribe the activities that are to be permitted activities for the purposes of s.20 of the EEZ Act and the conditions for undertaking these permitted activities. Under s.7 of the Regulations, seismic surveys (including VSP) are prescribed as permitted activities, subject to compliance with the Code.

2.1.2 *The Code*

The Code was developed by DOC and the current 2013 version came into effect on 29 November 2013 (DOC, 2013). The objective of the Code is to minimize acoustic disturbance to marine mammals from seismic operations including VSP. The guidelines outlined in the Code 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.

Under Section 4.3 of the Code, VSP (therein labelled borehole seismic surveys) is subject to the requirements for the applicable Level 1 or 2 surveys depending on the size of the acoustic source being used. 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, 2013).

Areas of Ecological Importance

Areas of Ecological Importance (**AEI**) are marine areas under the protection of the NZ government for their importance to marine mammals and other important marine species. The Project is located within an AEI, thus subject to additional requirements as outlined in the Code. DOC have agreed that Sound Transmission Loss Modelling will not be required and the provision of a single Marine Mammal Observer (**MMO**) and a single Passive Acoustic Monitoring (**PAM**) operator will suffice given the stationary and localized nature of the Project.

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 (**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 1 – 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, 1982*

The United Nations Convention on the Law of the Sea (**UNCLOS**) was concluded in Montego Bay, Jamaica, on the 10th of December 1982 and entered into force in 1994. The objective was to establish 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.

3 PROJECT DESCRIPTION

3.1 OVERVIEW

Anadarko proposes to undertake VSP during each of their drilling programs during February and March 2014. Drilling activity will take approximately 45 to 60 days per well, of which VSP will be undertaken over approximately 5 to 6 hours per well.

3.2 VERTICAL SEISMIC PROFILING

The following section provides information regarding the methods and equipment that will be used to undertake the VSP, which will be conducted from the drilling ship the *Noble Bob Douglas*.

3.2.1 Equipment

A range of equipment will be used to conduct the VSP. The following sub-sections outline this equipment.

Downhole Tool

The tool to be used for the VSP will be four shuttles Vertical Seismic Imager (VSI) tool configuration (**VSI-4**) (see *Table 3.1*). The tool will be configured for large hole with extension arms (12 ¼ to ~22 inch).

Table 3.1 ***Mechanical specifications for VSI Tool***

Temperature rating	177° C
Pressure rating	Standard: 20,000 psi
	High pressure: 20,000 psi
Borehole size – min.	7.62 cm
Borehole size – max.	55.88 cm
Outer diameter	Standard: 8.57 cm
	Slim: 6.35 cm
Length	Up to 317 m for up to 20 shuttles
Weight	Up to 998 kg
Tension	80,070 N
Compression	Standard: 22,240 N
	With stiffener: 44,480 N
Anchoring force	1,170 N in 7.62 cm hole
	915 N in 15.24 cm hole
	1,130 N in 31.75 cm hole
	951 N in 43.18 cm hole
Sensor package coupling force	285 N
Coupling force/sensor weight ratio	10:1

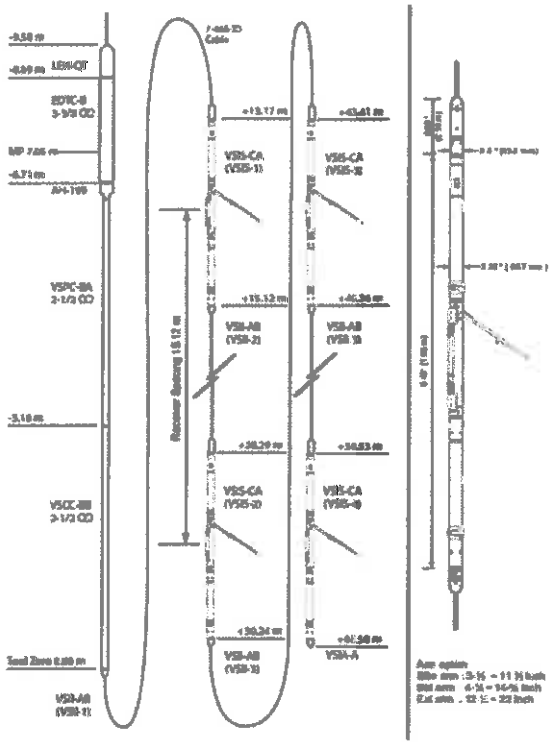


Figure 3.1 ***VSI-4 Tool Configuration***

Surface Equipment

Due to the depth of the well (2800 – 1855 m measured depth rotary table (MDRT)), 3 sets of air guns will be used, each with a volume of 250 cubic inches, totaling 750 cubic inches. The air guns will be configured in a delta frame and will be powered by either compressed nitrogen gas bottles or by compressor. The guns cluster will be fired at 1800 psi with shots fired at 20 – 30 seconds at the same station and five good shots per station will be stacked. The frequency band for the source sound emission to be used during the VSP is 0 to 130 Hz only with a maximum sound level of 195 dB re 1µPa@1m.

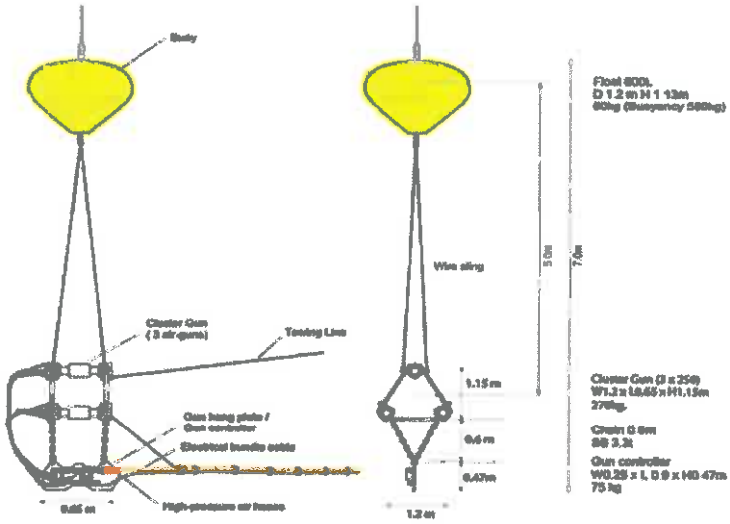


Figure 3.2 ***Gun cluster frame diagram***

3.2.2 *Data Acquisition*

Table 3.2 outlines the parameters for the data acquisition.

Table 3.2 ***Acquisition Parameters for the Project***

Survey Configuration	Zero-Offset VSP	
Downhole Tool	Downhole tool type	VSI-4
	Downhole sensor type	Geophone Accelerometer (GAC-D)
	Downhole tool conveyance	Wireline
	Sensor spacing	15.12 m
Surface Equipment	Recording system	VSI Workbench
	Source	3 X Sodera G Guns (250 cu in each)
	Source deployment	Rig Crane to deploy Gun overboard for ZVSP type survey
	Surface sensors	Fjord Instruments HD-1
	Source controller	TRISOR
	Source depth	5 m
	Source pressure	1800 psi
	HP gas supply	N2 Bottles/Compressor
Recording Parameters	Number of shots per station	5 repeatable shots per tool setting
	Downhole recording length	5000 ms
	Downhole sampling rate	1 ms
	Surface recording length	1000 ms
	Surface sampling rate	1 ms
	Reference datum	MSL
	Surface velocity	1524 M/S

3.2.3 *Time Estimate*

Data will be acquired across a series of stations within the borehole from a target depth of around 2,800 m MDRT to the sea bed at 1,105 m MRDT, or until the top of the cement around the well casings, whichever comes first. A total of 16 stations at 15.12 m intervals, with a total of approximately 95 shots, are being planned. However, depending on the cement behind the casings there could be more stations added, thus the acquisition time could vary. It is estimated in total, the seismic acquisition process for each well will require approximately 5 to 6 hours in total.

3.3 *ENVIRONMENTAL CONSIDERATIONS*

In compliance with the Code, MMOs and PAM operators will be present to manage the environmental aspects of the Project. The mitigation and management procedures outlined in the Code will be adhered to, under the supervision of a single PAM operator and a single MMO. For full scale seismic surveys that encompass larger scales (thousands of square kilometer's and multiple weeks) two PAM operators and two MMO's are present. However, given the nature and smaller scale of the current survey (localized, stationary, and ~5-6 hours), DOC has agreed that a two person PAM/MMO team is sufficient to ensure the Code is effectively implemented and impacts on marine mammals are effectively minimized. DOC has also agreed that, while the Project is located within an AEI, sound transmission loss modelling and subsequent ground-truthing will not be required. *Annex B* provides further information of the PAM system to be employed during the VSP activity. This PAM system (encompassing both the hydrophone element and data acquisition card) is considered to be appropriate by Anadarko's specialist MMO contractor, Blue Planet Marine, to meet the requirements of the Code ((1 Hz to 180 kHz range and to 360 Hz respectively).

3.3.1 *Soft Start Procedures*

The soft start procedure as outlined in Section 4.3.5 of the Code, recognizes that:

> *...alternative acoustic source technologies may be used for borehole seismic surveys, and that soft start may not be possible in the same manner as a conventional marine seismic source array.*

As such,

> *Where possible, initial activation of the acoustic source must involve the gradual increase of the source's power over a period of at least 20 minutes and no more than 40 minutes, unless the source is being reactivated after a break in firing less than 10 minutes before that time. In the case of borehole seismic surveying, activation of the acoustic source at least once within sequential 10 minute periods shall be regarded as continuous operation.*

The following soft start procedure will consequently be implemented in relevant situations as prescribed above:

- Start 500 psi firing at 60 second intervals for 5 minutes;
- Increase to 1000 psi firing at 60 second intervals for 5 minutes;
- Increase to 1500 psi firing at 30 second intervals for 5 minutes; then
- Increase to 1700 psi firing at 30 second intervals for 5 minutes.
- Increase to 1800 psi after 20 minutes total.

3.4 *SAFETY CONSIDERATIONS*

Two main considerations have been made as follows:

- Air gun and high pressure air equipment – ensure safety of people; and
- High pressure air equipment – prevent damage to rig structure by establishing a safe distance.

Figure 3.3 displays the 11 m safe distance that will be applied for the Project thereby ensuring the air guns will not cause damage to the rig structure.

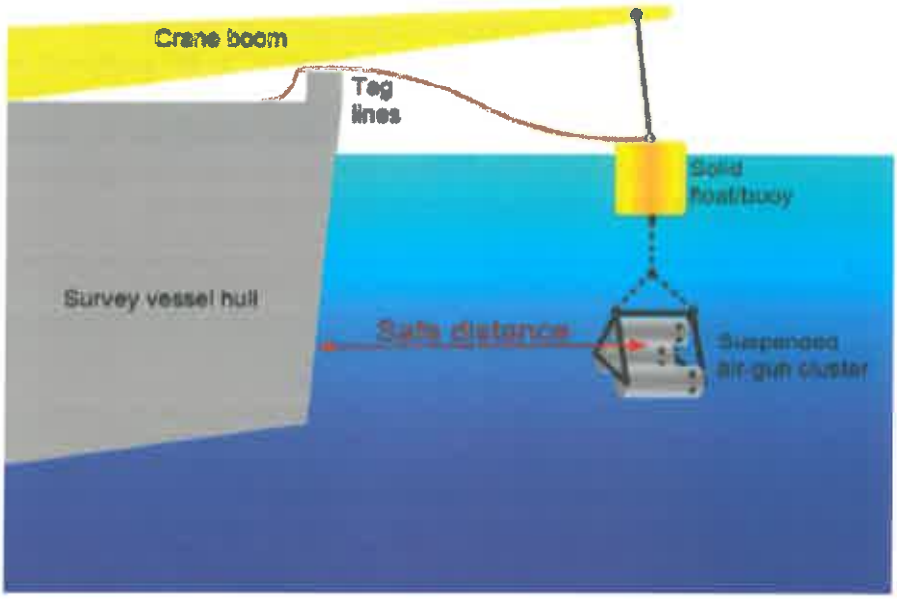


Figure 3.3 Deployment of the air gun cluster

4 EXISTING ENVIRONMENT

4.1 BIOLOGICAL ENVIRONMENT

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 ecological communities potentially present within the Project Area, which may be impacted by the Project activities.

4.1.1 *Benthic Communities*

This section addresses benthic communities with the exception of coldwater corals, which are addressed in the following *Section 4.1.2, Coldwater Corals.* Typical deep water benthic communities comprises of infauna (organisms living in the seabed) and epifauna (organisms living on the seabed). These organisms play important roles in marine ecosystems, including secondary production and bioturbation of sediments (Key, 2002). One of the major factors affecting the structure and function of deep ocean benthic communities is the availability of food (Gage and Tyler, 1991). Interest in deep sea benthic communities has increased considerably since the development of major deep-water fisheries in the late 1970s (Robertson, 1991 and Sullivan, 1991), but this has not been paralleled by increased understanding of ecosystem functioning of these areas (Probert *et al.*, 1997). No local studies of marine benthos in the Project Area were identified in the preparation of this MMIA and MMMP. It should however bee noted that in considering the potential benthic communities within the project area, a NIWA multi-beam study of the Canterbury Basin (NIWA, 2012) showed an absence of seamounts in the Project Area. Furthermore, a pre-dill monitoring survey of the Caravel drill location and the environments to a 2,000m radius from the dill site indicated that the surrounding environment was homogenous, flat and muddy. The results of this pre-drill survey have however not yet been issued to Maritime New Zealand.

In 2012, the Ministry for Primary Industries released a report that reviewed existing published and unpublished sources of information on soft-sediment marine assemblages around NZ (Rowden *et al.*, 2012). It is noted in the report that the vast majority (95%) of the data sources reviewed are post-1960 and spatially concentrated in areas with on-going land and coastal/aquaculture development and population growth and/or in close proximity to science researchers and institutes are located. The report further highlights that areas with relatively few records were reflective of the distance of these locations from human population centers; their inaccessibility; and their relative lack of soft sediment habitats. However, in the absence of specific studies focused on the Project Area, the Ministry for Primary Industries study provides an indication of the NZ benthic environment. The study identified a basic pattern of composition of soft-sediment macroinvertebrate assemblages coupled with some of the environmental factors that influenced their distribution.

The results of the study were published in 1969 (McKnight, 1969) concluding that assemblages correlated strongly to benthic sediments with four key communities being identified across four broad sediment types. In NZ, soft sediments (unconsolidated substrata such as mud, sand and gravels) are the most regularly found sediment type across the continental shelf, slope and deep-sea (Mitchell *et al.*, 1989).

In a study of benthic communities on the Chatham Rise and associated slopes, macrobenthic infauna biomass (dominated by polychaetes) was linked to surface water primary productivity and the resulting organic flux to the seabed (Probert and McKnight, 1993). Further work identified two deepwater epifaunal communities, comprising mainly echinoderms (McKnight and Probert, 1997). Both deepwater groups were associated with muddy sediment; 462–1693 m included *Ypsilothuria bitentaculata* and *Pentadactyla longidentis* (Holothuroidea), *Brissopsis oldhami* (Echinoidea), and *Amphiophiura ornata* (Ophiuroidea); and 799–2039 m included *Ophiomusium lymani* (Ophiuroidea), *Porcellanaster ceruleus* (Asteroidea), *Gracilechinus multidentatus* (Echinoidea), and *Aenator recens* (Gastropoda).

4.1.2 *Coldwater Corals*

Corals have been recorded in NZ waters from intertidal areas to a depth of up to 4954 m (Cairns *et al.*, in prep). Corals (from the phylum Cnidaria) can grow as individuals or in colonies and are vital to both offshore and coastal environments, where they provide food, shelter and structure for other marine species. There are growing concerns about the long term impacts of fishing and seabed mining activities on deep-sea corals, both within and outside NZ's EEZ. The Wildlife Act 1953 protects all 'black corals' and 'red corals' (Consalvey *et al.*, 2006). These corals are important as although the constructional diversity of deep water corals and reefs can be low, with only a few dominant species, these areas support very high faunistic diversity (Cairns and Stanley, 1981). Deep water corals are vulnerable to the effects (i.e., sedimentation) of dredging, drilling and anchoring, and deep sea fishing as they are fragile, sessile, slow growing, long lived, have a low natural mortality rate, can have limited larval dispersal and are restricted to certain habitats (e.g. seamounts), which are often the focus of commercial fisheries (Consalvey *et al.*, 2006).

Hydrocarbon exploration and production (typically indirect impacts such as sound and sedimentation), as well as trawling and mineral exploitation (both direct and indirect impacts) have been identified as a potential threat to deep sea corals (Consalvey *et al.*, 2006). Discussion relating to the impacts from this Project can be found in Section 6 of this MMIA.

Coral Bycatch

Records of coral bycatch observed in the Project Area held by MPI in three separate databases was requested by ERM and is presented in *Table 4.1*. The three databases reviewed were: Trawl (information collected on research trawls), COD (information collected by observers while aboard commercial fishing vessels); and NFPS (data reported by fishers on non-fish/protected species catch return).

Table 4.1: ***Recorded Coral Bycatch in region of the Project NOTE: The records show no incidence of coral bycatch within 100 km of the Project.***

Species Code	Weight (kg)	Date	Latitude (S)	Longitude (E)	Depth (m)
COU	10	Dec 2001	46.1	171.4	1170
COU	10	Sep 2002	46.3	171.2	1300
COU	50	Sep 2002	46.5	170.9	1013
COU	10	Nov 2002	46.2	171.4	1216
COU	10	Dec 2004	46.1	171.4	1065
COU	5	Dec 2004	46.1	171.4	1055
PAB	2	Oct 2006	46.0	171.4	1250
ISI	10	Oct 2007	46.4	171.2	1362
ISI	50	Oct 2007	46.1	171.4	1217
CHR	5	Nov 2007	46.2	171.4	1202
LLE	0.1	Nov 2008	46.4	171.2	1046
ACN	0.1	Dec 2008	46.5	171.0	1106
GOC	0.1	Dec 2008	46.1	171.4	1047
COU	5	Oct 2009	46.0	171.4	1223
GOC	2	Oct 2009	46.4	171.2	1200
GOC	5	Oct 2009	46.0	171.4	1240
BOO	0.4	Oct 2009	46.1	171.3	1139
GOC	0.1	Oct 2009	46.1	171.3	1139
GOC	0.1	Oct 2009	46.2	171.4	1204
GDU	0.2	Oct 2009	46.2	171.4	1205

Notes:

COU	*Coral Unspecified*
PAB	*Bubblegum coral: Paragorgia arborea*
ISI	*Bamboo coral (unspecified)*
CHR	*Golden corals: Chrysogorgia*
LLE	*Bamboo coral: Keratoisidinae lepidisis*
ACN	*Bamboo coral: Keratoisidinae acanella*
GOC	*Gorgonian coral (unspecified)*
BOO	*Bamboo coral: Keratoisidinae keratoisis*
GDU	*Bushy Hard coral: Goniocorella dumosa*

Although *Table 4.1* above shows that no incidence of coral bycatch has been observed within 100 km of the Project, the following section on black corals has been included for information. Impacts of seismic surveys on corals are also considered in *Section 6.3.1* as a conservative approach.

Black Corals

Around 58 species of black coral have been identified in NZ waters (Tracey *et al.*, 2005). These corals are important structure forming species (Morgan, 2005). Most black coral species have been recorded living on deep sea seamounts from 200 m to 1000 m deep (Cairns *et al.*, in prep). Colonies of black coral observed within the NZ waters have been reported to reach 10 m in height and some specimens have been aged at over 300 years (Consalvey *et al.*, 2006). All black coral species are protected under the *Wildlife Act, 1953.*

According to the NABIS database (MPI, 2013a), black corals are distributed off the east coast of the South Island, stretching along the Chatham Rise and as far south as Oamaru.

Black corals belong to the order Antipatharia, within the Anthozoa class. A total of 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 particular specimens have been aged at over 300 years (Consalvey *et al.*, 2006).

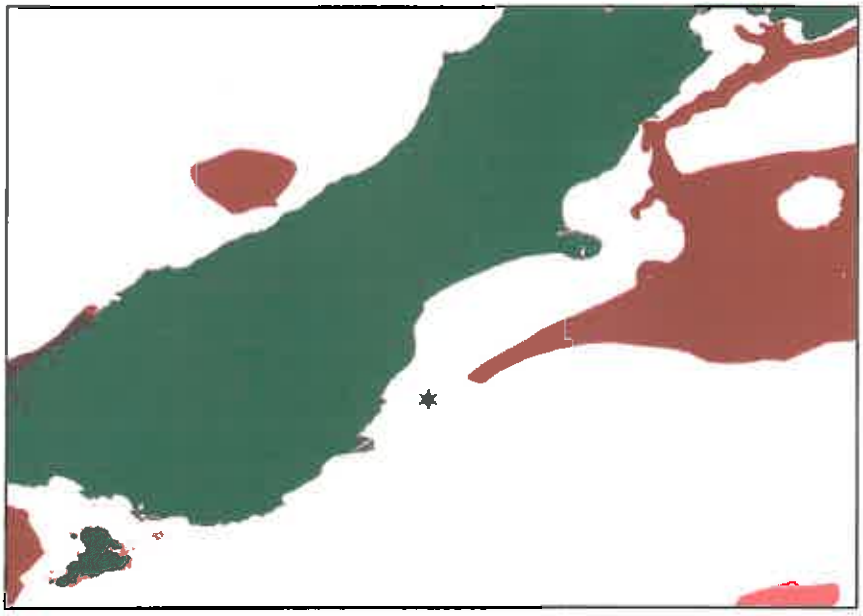


Figure 4.1 ***Distribution of black coral (red areas) around the Project Area which is depicted by the 'star'***

4.1.3 Fish Communities

Listed Fish Species

DOC classifies threatened species according to risk of extinction using criteria that have been developed specifically for NZ conditions. The list is updated every three years, with the last complete listing cycle from 2008 to 2011. Marine fish species did not however feature in the 2008 to 2011 published update and hence the 2005 listing still applies (DOC, 2011). In the 2005 listing, 82 species of marine fish are recorded as being in gradual decline, sparse, or range restricted (DOC, 2005). Some of these species may be found in the Project Area, but there is currently no comprehensive dataset on the occurrence or distribution of listed fish species within the Project Area.

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).

The Project Area falls within MPI's Southeast Coast Fisheries Region – Fisheries Management Area (**FMA**) 3 (MPI, 2013b). The customary and recreational significance, as well as the environmental importance of this region is rated as high by MPI. The commercial catch of this region is reported to be 6,177.04 tons.

The Southeast Coast Region comprises three main fisheries areas: Kaikoura, Canterbury and Otago. It contains NZ's second and third largest fishing ports – Lyttelton and Timaru – which are port to many deep sea trawlers.

In 2009, data were reported by MPI on the status of 119 stocks out of a total of 633 stocks managed under NZ's Quota Management System (**QMS**). Of these 119 stocks, 82 were considered near or above target levels set out in the *Fisheries Act 1996*. In 2010, 14 stocks were considered to be overfished. One of these overfished stocks is distributed across the Project Area; the orange roughy (see life history of this species below). Allowable catch levels of this fishery have been reduced to allow them to rebuild to target levels (MPI, 2009a).

Deepwater fishing activity occurs from 12 Nm from shore out to the 200 Nm limit of the EEZ, which incorporates the Project Area. Seventy percent of NZ's total fish catch is taken from deepwater fisheries. The majority of the fishing vessels operating in NZ's deepwater fisheries are large factory trawlers capable of spending 5 to 6 weeks at sea at a time. The following have been identified as important commercial deepwater fisheries potentially present in the Project Area. According to MPI (2009b) these species have habitat distributions which include the Project Area:

- Hoki (*Macruronus novaezelandiae*);
- Hake (*Merluccius australis*);
- Ling (*Genypterus blacodes*);
- Oreo (*Pseudocyttus maculates* and *Allocyttus niger*);
- Orange roughy (*Hoplostethus atlanticus*);
- Squid (*Nototodarus gouldii* and *Nototodarus sloanii*);
- Jack mackerel (*Trachurus declivis*, *T. novaezelandia* and *T. murphyi*); and
- Southern blue whiting (*Micromesistius australis*).

Table 4.2 shows the highest commercial catches reported for each of these species in statistical fishing block areas of the Canterbury Basin compared to the highest commercial catches reported in other individual fishing blocks within the EEZ over the fishing year of 2009/2010 (October – October), including all fishing methods (MPI, 2013a).

No catches were reported for the deepwater crabs or scampi fisheries over this period, indicating that these species are not currently abundant within the Project Area. Data was either withheld or no catches were reported for the orange roughy and data was unreliable for the southern blue whiting fisheries. Maximum catches reported for hoki, ling, squid and Jack mackerel in the Project Area are amongst the highest in the EEZ, indicating a likely abundance of this species, and therefore an important location for these particular fisheries. Life histories of these commercial deepwater fisheries species are summarized below.

Table 4.2 ***Highest Reported Commercial Catches for Deepwater Fisheries Statistical Areas within the Canterbury Basin, Compared to Other Fishing Blocks in the EEZ (2009/2010 Fishing year).*** *Source: MPI, 2013a*

Fishery Type	Highest Catches Reported in Fisheries Statistical Areas within the Canterbury Basin (kg)	Highest Catches Reported in the NZ EEZ (kg)
Hoki	1,860,000 to 16,700,000	1,860,000 to 16,700,000
Jack mackerel	400,000 to 11,300,000	400,000 to 11,300,000
Ling	155,000 to 1,710,000	155,000 to 1,710,000
Squid	23,000 to 14,000,000	23,000 to 14,000,000
Oreo (smooth)	20,000 to 540,000	54,000 to 2,250,000
Hake	8000 to 11,000	32,000 to 1,500,000
Orange roughy	No catch reported / Data withheld	412, 000 to 2,880,000
Deepwater crabs (king and giant spider)	No catch reported	1 to 10,000

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 are found around Stewart and Snares shelf, 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. Hoki inhabit depths of 10-900 m, but are most commonly found at depths of 200-600 m (MPI, 2010a).

Jack Mackerel

Jack mackerel fisheries consist of two NZ species, the greenback horse mackerel (*Trachurus declivis)* and yellowtail horse mackerel (*T. novaezelandia)*, and a third pan-pacific species, Chilean jack mackerel (*T. murphyi)*, which arrived in NZ in the 1980s. All three species are thought to be live close to the bottom at night and near surface during the day. All three species spawn through spring and summer. *Trachurus declivis* and *T. murphyi* are found throughout NZ waters and are likely to be present in the Project Area. The spawning distribution of these two species also occurs throughout NZ waters and along the Chatham Rise. These species inhabit depths ranging from 0-500 m (MPI, 2010g).

Ling

Ling are widely distributed through the middle depths (200–800 m) off NZ, particularly south of latitude 40° S. Ling appear to gather in numerous areas during a protracted spawning season. This is regionally variable, generally occurring from early spring through to summer. Spawning grounds include the Chatham Rise and 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, 2010c).

Squid

The NZ squid fishery consists of two species of arrow squid; *Nototodarus gouldii* and *Nototodarus sloanii*. Both species are found across the continental shelf in waters up to 500 m in depth, though they are most commonly found in waters less than 300 m in depth. The main spawning season is in winter. In general, *N. sloanii* hatches in July and August, with spawning occurring in June and July. *N. gouldi* may generally spawn one-two months before this. However, it is not known where these two species of arrow squid spawn (MPI, 2010f).

Oreo

Oreo species distributed across the Project Area include the smooth oreo (*Pseudocyttus maculates*) and warty oreo (*Allocyttus verrucosus*). These species are found throughout NZ waters from about 600 m to 1500 m in depth, with the smooth oreo occurring in slightly deeper waters than the warty oreo. Both species spawn on the South Chatham Rise in late October to at least December. They appear to have a pelagic juvenile phase, but little is known about this phase because juveniles are rarely caught. They are extremely long-lived species; the maximum age for the smooth oreo has been estimated at 86 years (MPI, 2010d).

Hake

Hake are distributed over the length of NZ waters. The species has a maximum age of 25 years. Maturity is reached between 6 to10 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. Hake are found throughout NZ at depths of 400-1100 m and their diet consists of other fish (MPI, 2010b).

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 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, 2010e).

Southern Blue Whiting

Southern blue whiting are synchronized batch spawners with four main spawning locations in NZ (all located outside of the Project Area). Spawning time varies with site, but generally is August-October. They are a schooling species most commonly found in sub-Antarctic waters of NZ at depths from 200-800 m (MPI, 2010h).

Sharks

The NABIS database (MPI, 2013a) identifies 11 shark species with distributions that include the Project Area. Only one of these species, the dark ghost shark (*Hydrolagus novaezealandiae*) is endemic to NZ. Two of these 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). Basking sharks and great white shark are listed as 'Threatened' on the IUCN Red List.

Great white and basking sharks are fully protected in NZ waters under the *Wildlife Act 1953*. It is illegal to hunt, kill or harm them within the 200 Nm limit. The school shark (*Galeorhinus galeus*) is common around coastal NZ and is dependent on estuaries or shallow coastal waters for nursery grounds and/or adult feeding grounds. Most sharks however, are large and mobile and are not restricted to small areas.

Oceanic pelagic species have global distributions, and individuals found in the NZ EEZ comprise only a small portion of the overall population. Sharks are known to inhabit the outer continental shelf and upper- to mid-continental shelf, and are typically demersal (living near the seabed) (WWF, 2010a).

4.1.4 *Marine Mammals*

Overview

The marine 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). According to the NABIS database (MPI, 2013a) and literature reviews, the marine mammals listed in *Table 4.3* are potentially present or transitory in the vicinity of the Project Area.

Table 4.3 Marine Mammals Potentially Present in the Project Area

Whales	Dolphin Family	Pinnipeds
Baleen Whales Humpback whale (*Megaptera novaeangliae*) Blue whale (*Balaenoptera musculus*) Minke whale (*Balaenoptera bonaerensis*) Sei whale (*Balaenoptera borealis*) Southern right whale (*Eubalaena australis*) Pygmy right whale (*Caperea marginata*) Fin Whales (*Balaenoptera physalus*) **Toothed Whales** Sperm whale s (*Physeter macrocephalus, Kogia breviceps, Kogia simus*) Beaked whales (21 species)	Common dolphin (*Delphinus delphis*) Long-finned and short-finned pilot whales (*Globicephala macrorhynchus* and *Globicephala melas edwardii*) Bottlenose dolphin (*Tursiops truncatus*) Southern Right-Whale Dolphin (*Lissodelphis peronei*) Hector's dolphin (*Cephalorhynchus hectori*) Killer whale (*Orcinas orca*) False killer whale (*Pseudorca crassidens*)	NZ Fur seal (*Arctocephalus forsteri*) Southern elephant seal (*Mirounga leonine*) New Zealand sea lion (*Phocarctos hookeri*)

Some species of large whales in the Southern Hemisphere migrate from the Pacific islands to the Antarctic Ocean each summer to feed (November – December) and then return each winter to the Pacific islands to breed (May – July) (DOC, 2007). *Figure 4.2* shows the distribution and migratory patterns of humpback, sperm, Bryde's and southern right whales.

Figure 4.2 ***Distribution and Migratory Patterns of Humpback, Sperm, Bryde's and Southern Right Whales in NZ Waters*** *Source: www.teara.govt.nz/en/whales/1/1*

Humpback Whale

Humpback whales 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 are reported to travel south 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). Estimated total population size as of 2008 was approximately 60,000 animals (IUCN, 2013).

Blue Whales

The blue whale (*Balaenoptera musculus*), is likely to be the largest animal to ever inhabit planet earth (Croll *et al.*, 2005; Figure 6.32). Like the humpback, the blue whale is part of the baleen suborder, and has four recognized subspecies being 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.*, 2008b).

Pygmy blue whales are listed as migrants within New Zealand waters (WWF, 2013b), occurring predominantly in the subantarctic zone of the Indian ocean between 0°E and 80°E (Cetacean Specialist Group 1996). The winter range for this species is virtually unknown, with scattered records from South Africa and Australia (Rice 1998). There are a small number of records of these whales within Cook Strait (Museum of NZ, 1998). Therefore, there is the possibility that this species may occur within the Project Area.

Blue whales are 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, and sightings of two sei whales in 1983 were recorded at the eastern end of the Chatham Rise (Patrick, *pers. comm.*).

The IUCN Red List notes blue whales as endangered, verging on critically endangered (Reilly *et al.*, 2008b). Although the global population is uncertain, the IUCN estimate that it is likely in the range of 10 000 to 25 000 globally, thought to be between 3 – 11% of the estimated 1911 population (Reilly *et al.*, 2008b). The endangered status of this species is a direct result of commercial harvesting of this species throughout the 20th century. It is thought that throughout this period more than 360 000 individuals were killed by whaling fleets in the Antarctic alone, and that thousands more were killed by Soviet fleets after being protected, during the 1960s and 1970s (WWF, 2012).

The blue whale is distributed throughout all oceans with the exception of the Arctic and some regional areas such as the Mediterranean, Okhotsk and Bering Seas (Reilly *et al.*, 2008b). While considered a migratory species, the migratory patterns of this species are not well understood (Reilly *et al.*, 2008b). However they are considered to be diverse with some remaining resident year round where high oceanic productivity provides regular food source, while other populations migrate to high-latitude feeding grounds. While known from New Zealand waters, little is known about their movement. However, a foraging population of pygmy and possibly Antarctic blue whales is thought to exist off the Taranaki coast, possibly a result of an aggregation of zooplankton in the area.

Minke Whale

Globally, there are now two recognized species of minke whale being the common northern minke whale (*Balaenoptera acutorostrata*) and the Antarctic/southern minke whale (*Balaenoptera bonaerensis*) (NOAA, 2012a). The northern minke is confined to the northern hemisphere. However, a sub-species, the dwarf minke is found in NZ. The Antarctic or southern minke whale is confined to the southern hemisphere, including NZ. These whales have been observed around the NZ coast, but are reported to be most common south of NZ, feeding in the Antarctic waters (DOC, 2009). 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).

Sei Whales

Sei whales (*Balaenoptera borealis*) are baleen whales of which two subspecies are recognized. The northern hemisphere subspecies is *B. b. borealis* and the southern hemisphere subspecies is *B. b. schlegellii* (Reilly *et al.*, 2008d). Living for between 50-70 years, sei whales filter feed, consuming copepods, krill, squid and small schooling fish (NOAA, 2012b).

Sei whales can be found worldwide staying mainly in water temperatures of 8 °C to 18 °C. In the southern hemisphere, sei whales migrate south to Antarctic feeding grounds in the summer months, they return to warmer waters to calve, migrating back up between NZ and the Chatham Islands (Hutching, 2009). Important areas for baleen whales include waters off Kaikoura, Cook Strait, and off the west coast of the South Island when baleen whales migrate between their feeding and breeding grounds (May-July and November-December) (Baker *et al.*, 2009). Sightings of two sei whales in 1983 were recorded at the eastern end of the Chatham Rise (Patrick, *pers. comm.*).

Due to a significant population reduction (up to 80%), the IUCN Red List lists the sei whale as endangered. From the late 1950s to mid-1970s sei whale stocks were seriously depleted, particularly in the southern hemisphere, where it is estimated that 200 000 sei whales were harvested during the 1905-1979 period (Reilly *et al.*, 2008d).

Southern Right Whale

The southern right whales 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. Southern right whales are reported to stay closer to shore than other species during migration (Boren, *pers. comm.*). 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 immediately north 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. 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).

Pygmy Right Whale

The pygmy right whale (*Caperea marginata*) 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).

Fin Whales

Fin whales (*Balaenoptera physalus*) are baleen whales of which two subspecies recognized. In the northern hemisphere exists the subspecies *B. p. physalus* while in the southern hemisphere exists the subspecies *B. p. quoyi* (Rice, 1998). Living up to 100 years, fin whales filter feed, consuming planktonic crustacean, some fish and cephalopods. In Antarctic waters, fin whales feed primarily on krill (*Euphausia superba*) (Nemoto, 1970).

Fin whales can be found worldwide, staying in offshore waters. They show well defined migratory movements between polar, temperate and tropical waters (Mackintosh, 1965). In the southern hemisphere, fin whales enter Antarctic waters however, the bulk of the fin whale summer distribution is 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). NZ is one of the aggregation areas for fin whales in the southern hemisphere (Gambell, 1985). The location and season in which pairing and calving occurs remain largely unknown (Mackintosh, 1965) because, unlike other large cetaceans, calving does not appear to take place in distinct inshore areas (Reeves *et al.*, 2002; Jefferson *et al.*, 2008).

Due to significant population reduction (more than 70%), the IUCN Red List lists the fin whale as endangered. Most fin whale populations were severely depleted by modern whaling from the early 1900's until their protection in 1975 (DEH, 2005).

Sperm Whale Family

Species of the sperm whale family are globally distributed and all three known species from the sperm whale family (large, pygmy and dwarf) have been recorded in NZ waters.

For the large sperm whale, typical habitats 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. They have a cosmopolitan distribution, and the migratory behavior of males differs from that of females. Southern Ocean males migrate south in summer and return north in winter. In NZ waters, a group of up to 20 young males exists for most of the year in the vicinity of the Kaikoura Canyon. Large sperm whales may occur in the immediate vicinity of the Project Area (*Figure 4.2*).

The large sperm whale is listed as a Migrant by DOC and as vulnerable by the IUCN Red List. 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 *et al.*, 2008e).

While pygmy sperm whales are found in deep (outer continental shelf and beyond) tropical to warm temperate zones of all oceans, dwarf sperm whales are thought to have even more of a preference for warmer waters (McAlpine, 2002; Taylor *et al.*, 2014). Accordingly, it is unlikely either species will inhabit the Project Area.

Beaked Whales

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. It has been inferred that most occur 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; however the Canterbury Basin has not been identified as a particularly significant habitat for these species.

Common Dolphin

Common dolphins (*Delphinus delphis*) are found in warm-temperate offshore waters in the Atlantic and Pacific. In NZ, the species tend to remain a few kilometers from the coast and while they are particularly common in Kaikoura and northward, including Bay of Plenty, Hauraki Gulf and Bay of Islands, they can also be found in the region of the Project (DOC, 2013c). Common dolphins are listed as not threatened by the DOC and of least concern by the IUCN.

Long-finned and Short-finned Pilot Whales

Pilot whales prefer waters along the continental shelf break and in areas of sharp topographic relief (WWF, 2010e). Long finned pilot whales (*Globicephala macrorhynchus*) are migratory and feed in offshore deeper water on fish and squid (WWF, 2010e). Short-finned pilot whales (*Globicephala melas edwardii*) prefer the warmer waters of the northern island (Taylor *et al.*, 2011). 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.

Long-finned pilot whales are listed as not threatened by the DOC and Data Deficient by the IUCN. Short-finned pilot whales are listed as migrants by the DOC and as Data Deficient by the IUCN. The IUCN Red List classifies both species as data deficient, however the global estimated population is around 750,000 (Taylor *et al.*, 2011).

Bottlenose Dolphin

Bottlenose dolphins (*Tursiops truncatus*) are widely distributed throughout cold temperate and tropical seas. NZ waters are the southernmost point of their range (DOC, 2013d). Within NZ waters, bottlenose dolphins are most commonly found the eastern North Island from Doubtless Bay to the Bay of Plenty; the north of the South Island from Cloudy Bay to Westport; and Fiordland, where the biggest group is found in Doubtful Sound (Hutching, 2012c). Bottlenose dolphins are listed as Nationally Endangered by DOC and of least concern by the IUCN.

Southern Right-Whale Dolphin

The distribution of the southern right-whale dolphin (*Lissodelphis peroni*) is poorly known, however they appear to be circumpolar and fairly common throughout its range (Jefferson *et al.*, 1994; Lipsky, 2002). Southern right-whale dolphins are most often observed in cool, deep, offshore waters with temperatures of 1 to 20°C (Taylor *et al.*, 2012b), with only occasional sightings in near shore environments (Jefferson *et al.*, 1994; Rose and Payne, 1991). This species feeds primarily on squid and fish (Jefferson *et al.*, 1994). Southern right-whale dolphins are listed as Data Deficient under the IUCN Red List (IUCN, 2013) and as 'not threatened' by DOC (2005).

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 (Hammond *et al.*, 2012a; Figure 6.47). Calving between November to around mid-January, the dusky dolphin has a lifespan of around 30 years (DOC, 2012k).

DOC has classified the dusky dolphin to be non-threatened in NZ, with an estimated national population of between 12,000 and 20,000 throughout NZ waters (DOC, 2012k). However, the IUCN Red List classifies this species as data deficient (Hammond *et al.*, 2008a). With a widespread distribution in the southern hemisphere, the main New Zealand populations occur in Kaikoura and the Marlborough Sounds (DOC, 2012k). While NABIS does not include the Project Area as part of the dusky dolphin's distribution, they are thought to potentially occur in the Project Area.

Hector's Dolphin

The Hector's dolphin (*Cephalorhynchus hectori)* is endemic to New Zealand 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. 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.* (2004), differences over such a small geographic scale have not been observed in any other marine mammal. The estimates of east-coast south island population of this species are currently 9,130 dolphins (CV = 19%; 95% CI = 6,342-13,144) in summer 2012/2013 and 7,456 dolphins (CV =18%; 95% CI = 5,224-10,641) in winter 2013 (MPI, 2013f).

Hector's dolphins are typically found in shallow coastal waters, typically less than 100 m deep and generally within 15 nm of the shore (Rayment *et al.*, 2003). MPI (2013f) notes that in recent studies, most sightings of Hector's dolphins have been in water depths less than 100 m. Distribution from shore can vary seasonally, and for the purposes of this present study it is assumed that they may occur within the Project Area, although the Project is located in an area that is much deeper than the shallow waters this species is typically found and research into species distribution is still ongoing.

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 (2005).

Killer Whale

It is estimated that there are three killer whale (*Orcinas orca*) populations in NZ waters, one off the North Island, one off the South Island, and a third group that spends its time in both regions (Hutching, 2012d). Killer whales have a diverse diet and feed on fish, cephalopods, sea birds, turtles and even other marine mammals (DOC, 2013).

Killer whales are listed as Nationally Critical by DOC and as Data Deficient by the IUCN. 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).

False Killer Whale

False Killer whales (*Pseudorca crassidens*) are generally found in tropical to warm temperate seas (Stacey *et al.*, 1994; Odell and McClune, 1999), preferring relatively deep, offshore waters. 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), eighty-four percent of the individuals stranding are in three species: false killer whales, pilot whales, and sperm whales. False killer whales are listed as data deficient under the IUCN Red List (IUCN, 2013).

NZ Fur Seal

The NZ fur seal (*Arctocephalus forsteri)* is known to forage along shelf breaks at sea so could possibly be encountered in the Project Area during feeding. Important breeding habitat has been identified as rocky shores and islands in the South of NZ, including the Banks and Otago Peninsulas (WWF, 2010f). They are known to forage along shelf breaks at sea and are also known to be attracted to the sound emitted from offshore rigs. Adult males arrive at breeding colonies first from late October, followed by females in late November. Pups are born around January and weaned in July/August when the females return to sea.

Southern Elephant Seal

The southern elephant seal (*Mirounga leonine*), also known as ihupuku or ihu koropuka (Maori name), is a member of the Phocidae family. Southern elephant seals range throughout the Southern Ocean around the Antarctic continent and on most subantarctic islands (DOC, 2012i). In winter, they frequently visit the Auckland, Antipodes and Snares Islands, less often the Chatham Islands and occasionally various mainland locations, from Stewart Island to the Bay of Islands (DOC, 2012i).

Globally, the southern elephant seal has four distinct population stocks and breeding colonies; the Peninsula Valdes stock in Argentina, the South Georgia stock in the South Atlantic Ocean, the Kerguelen stock in the south Indian Ocean and the Macquarie stock in the southern Pacific Ocean (McMahon *et al.*, 2003).

Elephant seals are wide-ranging, pelagic, deep-diving (average of 400–600 m) predators that typically travel to open waters and continental shelf edges thousands of kilometres from their land breeding colonies (Campanga *et al.*, 2007). The southern elephant seal is listed as Nationally Critical under DOC (DOC, 2005), and of least concern under the IUCN (IUCN, 2013) red list.

NZ Sea Lion

NZ sea lions (*Phocarctos hookeri*), also known as Whakahao (male) or Kaki (female) (Maori name) 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. NABIS shows the waters surrounding these islands and the coasts off the Catlins and Dunedin as a hotspot for these species, with breeding populations occurring along the Otago coast and on Auckland and Campbell Islands (DOC, 2012j).

Female NZ sea lions can travel up to 175kms from the coast to feed, diving to depth of up to 700m although most dives are only up to 200m in depth (DOC, 2012j). Females reach maturity from 3 years of age, with a life expectancy of up to 21 years (DOC, 2012j). The NZ sea lion is listed as Range Restricted by DOC (2005) and as Vulnerable under the IUCN (IUCN, 2013) Red List.

Listed Marine Mammal Species

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 (see *Table 4.4*). As a result of the 2008-2011 update, the threat status of two species was raised, with the NZ sea lion (*Phocarctos hookeri*) raised to Nationally Critical and the bottlenose dolphin (*Tursiops truncatus*) raised to Nationally Endangered. Five 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 (see *Table 4.4*):

- Killer whale (*Orcinus orca*) (Critically Endangered);
- NZ sea lion (*Phocarctos hookeri*) (Nationally Critical);
- Southern elephant seal (*Mirounga leonine*) (Nationally Critical);
- Southern right whale (*Eubalaena australis*) (Endangered); and
- Bottlenose dolphin (*Tursiops truncatus*) (Endangered).

Table 4.4 Species Listed On the NZ Threat Classification List as Critically Endangered, Nationally Endangered, or Range Restricted

Common and Scientific Name	NZ Threat Classification	Biology	Local Distribution	Timing of Appearance in Project Area
Bryde's whale *(Balaenoptera edeni)*	Nationally Critically Endangered	Generally a coastal species although can occur in the open ocean. Bryde's whales prefer more temperate waters and are seen off the NZ coast in and north of the Bay of Plenty. Rarely venture beyond 40 degrees south.	Unlikely to be encountered in the Project Area due to affinity for temperate waters.	Unlikely to occur
Killer whale *(Orcinus orca)*	Nationally Critically Endangered	Feeds on other marine mammals at sea and mostly fish inshore. No seasonal breeding or migration patterns observed. Presumed to breed throughout the year and to migrate based on the availability of prey.	Largely unknown. Killer whales are widespread throughout the temperate South Pacific. Likely to occur as a transient in the Project Area.	Year round
Maui's dolphin *(Cephalorhynchus hectori)*	Nationally Critically Endangered	Inshore species Considered a subspecies of Hector's dolphin	Thought to remain close to shore (within 4 nautical miles) and on the North Island of NZ only. Unlikely to occur in the Project Area due to affinity for coastal areas and North Island distribution.	Unlikely to occur
Southern elephant seal *(Mirounga leonina)*	Nationally Critically Endangered	Feeds on squid, cuttlefish and large fish. Comes ashore on islands and some mainland areas to breed in spring and in summer to molt; otherwise lives mostly at sea.	Range throughout the Southern Ocean around the Antarctic continent and on most subantarctic islands. In winter, they frequently visit the Auckland, Antipodes and Snares Islands, less often the Chatham Islands and occasionally various mainland locations, from Stewart Island to the Bay of Islands (DOC, 2012i).	Winter Months

Common and Scientific Name	NZ Threat Classification	Biology	Local Distribution	Timing of Appearance in Project Area
Southern right whale *(Eubalaena australis)*	Nationally Endangered	Feeds on krill Present offshore and inshore Mate and calve during winter in sheltered harbors, predominately the sub-Antarctic Auckland Islands and Campbell Island. May move far out to sea during feeding season; however give birth in coastal areas (American Cetacean Society, 2010).	Likely occurs as a transient in the Project Area during feeding.	Most prevalent over summer feeding months.
Hector's dolphin *(Cephalorhynchus hectori)*	Nationally Endangered	Inshore species, although have been sighted up to 18 Nm from the coast. Little known about migratory, reproductive, or feeding habits.	Patchily distributed around the South Island coast. Unlikely to be found in Project Area due to affinity for coastal areas.	Unlikely to occur within Project Area, but interaction may occur during vessel transit.
NZ sea lion *(Phocarctos hookeri)*	Nationally Critical	Feeds on fish, invertebrates, and occasionally birds or other seals. Breeding occurs in summer, pupping occurs in December	Annual distribution ranging from the southern coast of the South Island down and throughout the waters surrounding both the Auckland Islands and Campbell Island. NABIS shows the waters surrounding these islands and the coasts off the Caitlans and Dunedin as a hotspot for these species, with breeding colonies known along these coasts. It is assumed this species may occur within the Project area year round.	Year round
Bottlenose dolphin *(Tursiops truncatus)*	Nationally Endangered	Resident Bottlenose dolphins are found off the east coast of the North Island, the northern tip of the South Island, and in Doubtful Sound.	Two sightings of bottlenose dolphins have been reported along the Chatham Rise (Patrick, *pers. comm.*) therefore transients may be present in the Project Area during feeding.	Year round

4.1.5 *Marine Reptiles*

Seven species of marine reptiles are known to occur off NZ's coast (WWF, 2010g). 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). Marine reptiles are likely to breed on beaches located in tropical or subtropical areas outside of the NZ region (WWF, 2010g). The leatherback turtle is unique among sea turtles in its ability to withstand cooler waters, and consequently it is the most widely distributed marine reptile off NZ (WWF, 2010g). Leatherback turtles are thought to have resident feeding grounds within the NZ region and sightings have been recorded on the west coast of the South Island, Kaikoura, Banks Peninsula and as far south as Otago Peninsula and the Chatham Islands (WWF, 2010g).

4.1.6 *Protected Natural Areas in the Vicinity of the Project Area*

According to available information, there are no Protected Natural Areas located within the Project Area (UNEP and IUCN, 2009). The VSP activity is located in DOC's designated AEI for marine mammals, however as noted in Section 2.1.2 above, various exclusions from the requirements of seismic surveys within AEI have been agreed with DOC. A number of protected areas have been identified along the coastline of the east coast of the South Island, which are described below and shown on *Figure 4.3*.

The closest Protected Natural Area is the Pōhatu (Flea Island) Marine Reserve located on the south-east side of Banks Peninsula approximately 150 km from the Project Area. This marine reserve is important for a number of marine and terrestrial species, including endangered hoiho (yellow eyed penguin), Hector's dolphins and NZ fur seals (DOC, 2010c).

Other protected natural areas in the vicinity of the Project Area include the mātaitai and taiapure customary local fisheries grounds. These consist of the East Otago and Akaroa Harbour taiapures (30 and 150 km from the Project Area respectively), and the Rapaki, Koukourarata, and Wairewa/Lake Forsyth mātaitais (all located in the vicinity of the Banks Peninsula approximately 150 km from the Project Area).

In November 2007, the government established 17 Benthic Protection Areas (**BPAs**) (MPI, 2009c) that close areas within NZ's EEZ to bottom trawling and dredging. These BPAs protect the biodiversity within about 1.1 million km^2 of seabed – approximately 30% of the EEZ. The closest BPA to the Project Area is the Mid Chatham Rise BPA, located approximately 500 km to the north east. There are no BPAs located inside the Project Area.

The Banks Peninsula Marine Mammal Sanctuary (**MMS**) is the closest MMS to the Project Area at approximately 90 km from its northern boundary and 200 km north from the proposed exploration well drill location and approximately 220 km north of the optional appraisal well (see *Figure 4.3*). The boundaries extend from the mouth of the Waipara River north of the Banks Peninsula, to the Rakaia River in the south. The sanctuary's offshore boundary extends from mean high water springs to the 12 Nm territorial sea limit. The total area of the sanctuary is approximately 413,000 ha and covers 389.31 km of coastline. The primary purpose of this MMS is to mitigate threats to Hector's dolphin and therefore the sanctuary restricts activities such as fisheries, seabed mining activities and acoustic seismic survey work (DOC, 2010c).

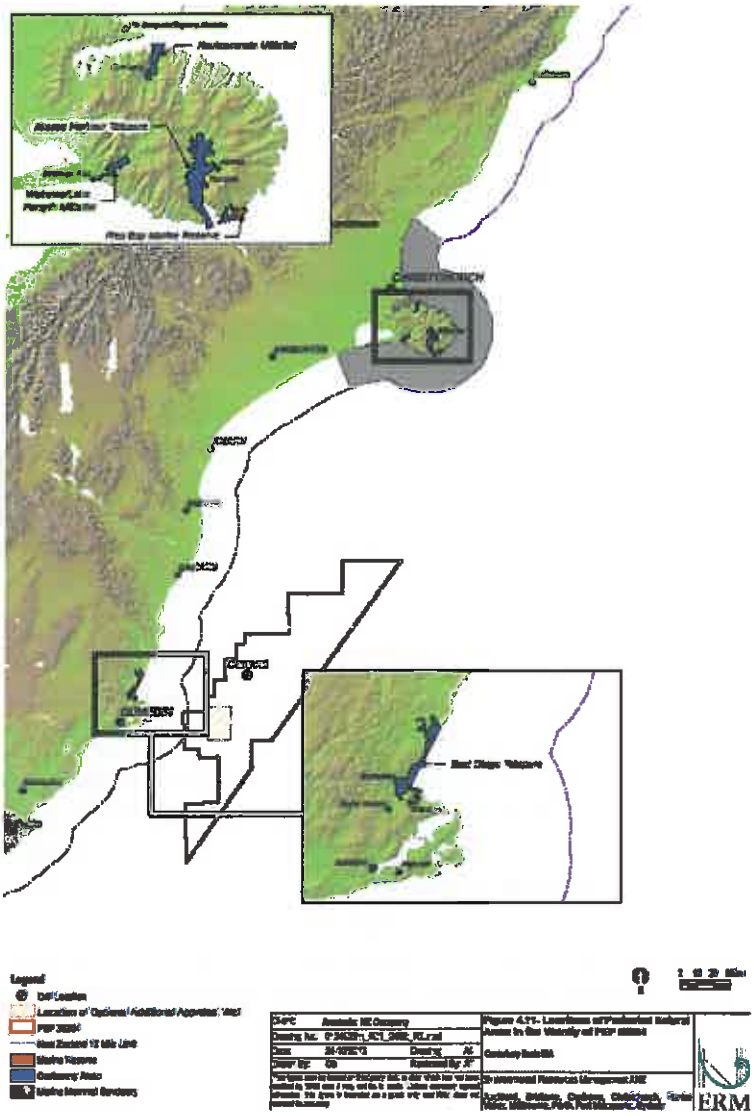


Figure 4.3 *Locations of Protected Natural Areas in the Vicinity of the Project Area*

4.2 EXISTING INTERESTS

Existing interests are defined in the EEZ Act as:

"the interest a person has in –

a. *Any lawfully established existing activity, whether or not authorized by or under any Act or regulations, including rights of access, navigation and fishing;*

b. *Any activity that may be undertaken under the authority of an existing marine consent granted under section 62;*

c. *Any activity that may be undertaken under the authority of an existing resource consent granted under the Resource Management Act 1991;*

d. *The settlement of a historical claim under the Treaty of Waitangi Act 1975;*

e. *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;*

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

This section describes the socio-economic and cultural aspects of the southern NZ region and identifies the existing interests that could be affected by the activity as per the requirements of Section 39(d) of the EEZ Act. As such, the discussion is limited to the socioeconomic components of the environment that could impact, or be impacted, by the proposed exploration activities. Particular emphasis is placed on the socio-economic and cultural conditions of the Canterbury and Otago regions, which are located on the east coast of the South Island, and are the nearest regions of the country to the Project Area.

4.2.1 *General Demographics*

The Canterbury region occupies an estimated land area of 45,238 km² and is NZ's largest region (Environment Canterbury, 2010). It is bounded by the Pacific Ocean to the east, the Marlborough and Tasman regions to the north and northwest, the West Coast region to the west and the Otago region to the South.

The Otago region is the second largest NZ region by land area, occupying approximately 32,000 km² or 12% of NZ's land area (Otago Regional Council, 2009). It is bounded to the southwest by Southland region, to the northwest by the West Coast region, to the north by Canterbury region and to the east by the Pacific Ocean.

Population

According to the 2013 census data, the population of NZ was 4,242,048, and had grown 5.3% since 2006 (Statistics NZ, 2014a). The Canterbury region was the second largest NZ region by population, accounting for 539,436 persons, approximately 13% of the total national population. The Otago region had a population of 202,467 persons (5% of the NZ population), ranking seventh in population size out of NZ's 16 regions (Statistics NZ, 2014b). The main settlement in the Canterbury region is Christchurch, the largest settlement on the South Island, whilst Otago's main settlement is Dunedin.

Ethnic Composition

The largest ethnic group in NZ in 2013 was the "NZ European" group, which accounted for approximately 2.97 million people, or 70% of the population. The next largest ethnic group nationwide was Māori, which accounted for 598,602 people, or 14.1% of the population. The remainder of the population was comprised of people of Asian, Pacific, Middle Eastern, Latin American, African, or other origins. In 2013, NZ had a rather large and growing immigrant population: almost one quarter (23.6%) of people living in NZ in 2013 were born overseas, compared with 22.9% in 2006, 19.5% in 2001, and 17.5% in 1996 (Statistics NZ, 2014b).

In 2013, the Canterbury region was slightly less ethnically diverse than NZ as a whole. In 2013, people of NZ European descent accounted for 83.2% of the Canterbury region's population. The 2013 census results also indicated that the next largest ethnic group in the Canterbury region was Māori (7.8%), 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. 18.6% of the Canterbury population were immigrants, having been born overseas, compared with 23.6% for NZ as a whole. In the Otago Region, 84.8% of the population were of European descent, with 7.1% belonging to the Māori ethnic group. 17.2% of the Otago population were immigrants.

Income

The median personal income for people aged 15 and over in NZ was NZ$28,500 in 2013. This figure was up 16% from NZ$24,400 in 2006 (Statistics NZ, 2014b). The regions with the highest median annual personal incomes in 2013 were Wellington, Canterbury, and Auckland, while the regions with the lowest median annual personal incomes were the Northland, Gisborne, and Manawatu-Wanganui. Median annual incomes in the Canterbury (NZ$30,100) were higher than the national median, likely due to the Christchurch rebuild, whilst the median annual income in Otago was slightly below the national median annual at NZ$26,300 respectively.

4.2.2 *Maritime Traffic, Ports and Harbours*

NZ has thirteen major commercial ports and harbours.

There are three major commercial ports on the eastern coast of NZ's South Island, adjacent to the Project Area: Lyttleton (Christchurch), Port Otago (comprising Dunedin and Port Chalmers) and Timaru. The anticipated initial shore base for the exploration and optional appraisal well drilling activity is however Port Taranaki (New Plymouth).

Lyttelton Port is the South Island's major deep-water port and is located approximately 160 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).

The most centrally located South Island port is PrimePort Timaru, located approximately 110 km from the Project Area. PrimePort Timaru provides a 24-hour a day pilot service all year round (Business New Zealand, 2010). The port has seven berths capable of handling a range of cargoes, from bulk liquids, diesel bunkers and containers, to reefer exports, bulk chemicals and grain (Prime Port Timaru, 2004).

Otago Harbor is located on the eastern seaboard of the South Island, adjacent to Dunedin (approximately 30 km from the Project Area). Port Otago is the second largest port in the South Island and operates two wharf systems - Port Chalmers and Dunedin. The Port Chalmers container facility handles the largest container vessels that call at NZ's ports (Business New Zealand, 2010). Port Chalmers has four berths, suitable for handling containerized, multipurpose and conventional or RoRo vessels. The Dunedin wharf system is suitable for vessels with a lower draught. Tankers, fishing vessels and smaller conventional vessels are the principal users.

Port Taranaki (New Plymouth) is anticipated to be the initial shore-base. It offers nine fully serviced berths for a wide variety of cargoes and vessels. The maximum port draft is 12.5 m, and for vessels in excess of 10m Dynamic Under Keel Clearance must be used. Port Taranaki has the ability to handle a wide diversity of cargoes including all forms of bulk products (liquid and dry), containerized, and break-bulk products (general, refrigerated or palletized), and has specialist experience in the handling of heavy lift and project cargoes. All wharves are supported by covered and open storage areas.

There are no designated shipping lanes within the vicinity of the permit 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 but this is expected to be a very low volume. 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).

4.2.3 *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 Fisheries

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.

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. 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.

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 seventh-largest employment categories in NZ in the 2013 census (Statistics NZ, 2014a). Approximately twice as many men are employed in these industries as women. The Canterbury and Otago regions employed the second and sixth highest number of people in the agriculture, forestry and fishing sector respectively (Statistics NZ, 2013b), although the proportion of fishers within this category is not known.

Recreational Fisheries

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.

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).

Customary Fisheries

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.

The Kaimoana Customary Fishing Regulations 1998 and the Fisheries (South Island Customary Fishing) Regulations 1998 strengthen some of the rights of tangata whenua to manage their fisheries. No customary areas as established under the Fisheries Act 1996 and Kaimoana Customary Fishing Regulations 1998 have been identified in the Project Area, either through literature review, or during engagement of iwi. Various special management areas (mātaitai reserves and taiapure) have however been identified in the coastal areas along the east coast of the South Island of NZ (see *Figure 4.3*).

4.2.4 *Oil and Gas Activity*

The Canterbury Basin has a proven petroleum system and large mapped structures; however the region remains very lightly explored. To date, 11 wells have been drilled in the Canterbury Basin. Onshore wells drilled have been dry, including the recent Arcadia-1 and Ealing-1 wells. The four offshore wells drilled during the 1970s and 1980s, Endeavour-1, Resolution-1, Clipper-1, and Galleon-1 are more indicative of the basin's potential.

Both Galleon-1 and Clipper-1 contained significant hydrocarbon shows in Late Cretaceous coal measure sands (NZ Petroleum and Minerals, 2012). Galleon-1 flowed gas at 10 million standard cubic feet per day with 2300 bbls per day condensate, but was plugged and abandoned as the calculated recoverable reserve was considered uneconomic. No further information on Clipper-1 was identified.

4.2.5 *Munitions Dump*

Information collected from Maritime NZ and the Royal New Zealand Navy notes the presence of a munitions dumping ground in the south western corner of the Project Area, adjacent to the Otago Peninsula. Further correspondence with Maritime NZ and the Royal New Zealand Navy, along with the acquisition and review of naval archives regarding offshore dumping revealed that approximately two tons of World War II era anti-aircraft munitions were potentially dumped in the identified dumping ground.

Anadarko does not intend to drill in or adjacent to the identified munitions dump location, hence no interaction between the munitions dump and exploration/appraisal program is anticipated.

4.2.6 *Tourism*

Various tourism companies operate from coastal locations including the Otago Peninsula, Banks Peninsula and Kaikoura. Popular activities include wildlife cruises, hiking, natural heritage and historical sightseeing, canoeing and kayaking. While many activities are based on land, within inland waters or within harbors such as Akaroa Harbor and Lyttelton Harbor at Banks Peninsula, some companies operate further offshore to provide whale and albatross tours and offshore fishing charters. For example, Kaikoura (240 km north of the Project Area) is a popular whale watching area as the continental shelf is close to shore and upwellings in the area attract numerous bird species, whales and dolphins. Banks Peninsula (100 km north of the Project Area) also provides some offshore wildlife cruises. However, the rough seas, changeable weather and distance from the coast limit tourism in offshore waters near the Project Area.

4.2.7 *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 exploration and optional appraisal well drilling activity. There are no known shipwrecks or sites of heritage significance within the Project Area.

4.2.8 *Cultural Environment*

As highlighted previously, the 2013 census identified that Māori comprise 7.1% and 7.8% of the population in Otago and Canterbury respectively. Te Kāhui Māngai, a directory of iwi and Māori organizations developed by Te Puni Kokiri (the Ministry of Maori Development), highlights that the main iwi in the South Island of NZ are Ngāi Tahu. According to Ngāi Tahu, the iwi hold the rangatiratanga or tribal authority over 80 per cent of the South Island (Ngāi Tahu, 1996a). Within the iwi, there are five primary hapū, being Kāti Kurī, Ngāti Irakehu, Kāti Huirapa, Ngāi Tūāhuriri and Ngāi Te Ruahikihiki (Ngāi Tahu, 1996b).

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.

The importance of the coastal and marine environments to Māori in the southern regions of NZ both in the spiritual and physical contexts is highlighted in iwi-developed management plans such as the Ngai Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008, Te Tangi a Tauira - The Cry of the People (Ngāi Tahu ki Murihiku, 2008) and the Kāi Tahu ki Otago Natural Resource Management Plan 2005 (Kāi Tahu ki Otago, 2005).

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 also *Section 1.5* above and *Annex A*). 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 exploration and optional appraisal well drilling 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.

The engagement program has included meetings and hui with Te Runanga o Ngai Tahu leadership as well as a number of hapu with an identified interest in Anadarko's activities. Anadarko has also engaged regularly with Kai Tahu Ki Otakou, seeking advice and input on its iwi engagement program.

Anadarko has briefed Nga Kaihautu – the EPA's Maori Advisory Board – on its engagement activity, and has met with EPA staff on a number of occasions to discuss progress and seek advice in this area.

Anadarko has also had a number of interactions with Maori media to ensure information reaches a wider iwi audience than those attending meetings.

A Cultural Impact Assessment (**CIA**) is being prepared on behalf of the iwi for the broader project activities. The purpose of the CIA is to provide an analysis of the cultural and socio-economic potential adverse effects of the project activities on the people, lands, waters and wider environment of iwi.

5 IMPACT ASSESSMENT METHODOLOGY

This section describes the methodology adopted for identifying and assessing impacts of Anadarko's proposed exploration well drilling activity 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 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.

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 VSP) 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

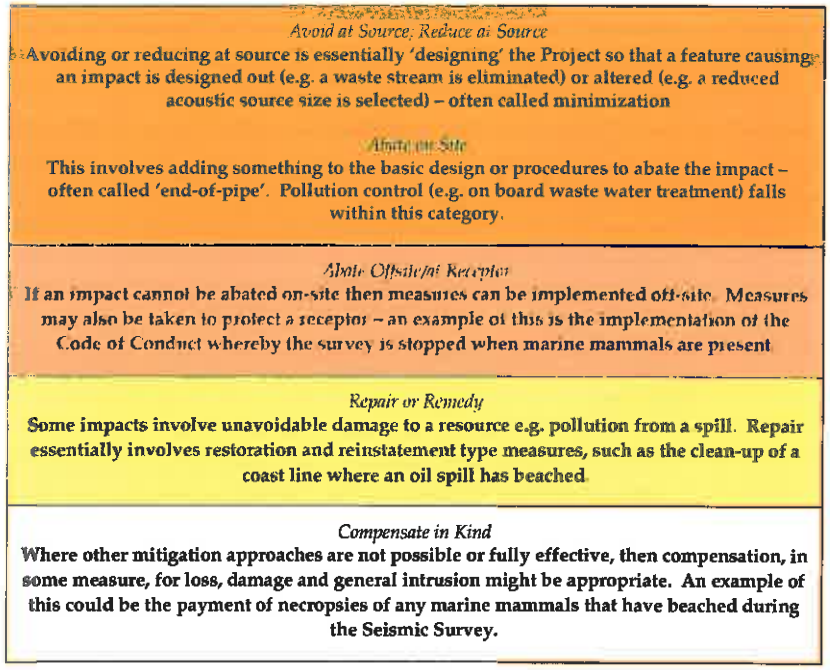
- *Local*: impacts that affect locally important environmental resources or are restricted to a single habitat/biotope, a single (local) administrative area, a single community.
- *Regional*: impacts that affect regionally important environmental resources or are experienced at a regional scale as determined 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.

5.2 ASSESSMENT METHODOLOGY STAGE II: DEVELOPING MITIGATION MEASURES

A key component of the MMIA 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), 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 *Figure 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.

Figure 5.2 ***The Mitigation Hierarchy for Planned Project Activities***



5.3 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 MMIA 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 MMIA, 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 MMIA 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, Administrative Framework*), 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 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 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 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. 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 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 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 MMIA*

		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.

These categories of significance for environmental impacts are defined in *Box 5.3*. These general definitions of Categories of Impact Significance have been applied to the assessment of impacts for Anadarko's proposed exploration/appraisal program.

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.

5.4 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.

5.5 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 • No sensitive resources impacted • Rapid degradation of spilled materials and rapid recovery of affected resources
Medium	• Localized environmental damage • No sensitive resources impacted • Degradation of spilled materials and full recovery of affected resources
High	• Severe environmental damage • Sensitive resources impacted • Recovery of affected resources is very slow

Table 5.6 *Unplanned Event Impact Significance Criteria*

Likelihood	Severity of Impact: Low	Medium	High
Extremely Unlikely	Negligible	Negligible	Negligible
Unlikely	Negligible	Minor	Moderate
Possible	Minor	Moderate	Major
Likely	Moderate	Major	Major

5.6 EVALUATION CRITERIA FOR ACCIDENTAL OR UNPLANNED EVENTS

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.

5.7 DEALING WITH UNCERTAINTY IN THE ASSESSMENT OF IMPACTS

Impact assessment is a process that deals with the future, and there is inevitably uncertainty that arises between the predictions made and what will actually happen during the course of the Project. However, the deepwater exploration/appraisal 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 exploration 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 MMIA team has used its professional experience to judge whether a significant impact is likely to occur or not.

6 VERTICAL SEISMIC PROFILING IMPACT ASSESSMENT

6.1 INTRODUCTION

Sources of environmental impacts from the planned single exploration well drilling activity may include routine operations that occur as part of the standard procedures described in *Section 3, Project Description*, or non-routine events or incidents. This assessment considers how the various components of these routine and non-routine activities could affect the environment within the Project Area.

6.2 IMPACT ASSESSMENT SCOPE

This impact assessment considers the impacts of Vertical Seismic Profiling during Anadarko's planned exploration well drilling activity on relevant environmental resources and receptors. It addresses all impacts that will occur and may occur during the VSP.

The impact assessment draws upon the Project Description provided in *Section 3, Project Description*, and *Section 4, Existing Environment*, and as such should be read in conjunction with these sections.

Environmental impacts which have been identified as likely to occur, but of insignificant consequence, are presented in *Table 6.1*. Interactions that are considered to be of likely significance as a result of the project drilling activities are presented in *Table 6.2* and will be the focus of this impact assessment.

Table 6.1 Environmental Impacts from Project Activities Considered to be of Unlikely Significance

Resource/ Receptor	Justification for Expectation of Insignificant Impact
Seawater Quality	Although deployed into the sea, there will be no discharges released directly from the VSP operating equipment. Potential impacts to seawater from VSP activities are therefore considered to be negligible.
Marine vessels	Given the limited duration of the VSP activity (7-8 hours), limited number of vessels and area used by the Project, 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. As such, they are unlikely to be subject to any impacts of significance.
Seabirds	No additional surface infrastructure of significance will be required for this Project and no additional discharges of waste will be required. Therefore, it is unlikely that any impacts will occur on seabirds.

Resource/ Receptor	Justification for Expectation of Insignificant Impact
Public health and safety	Given the remote location of the Project it is unlikely there will be any interaction with public as a result of Project activities. In the unlikely event that anything or anyone approaches the drilling location, 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.

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

Activity	Environmental Impact Description
Source sound emissions (*Section 6.3*)	Physiological effects on marine fauna from exposure noise or associated pressure effects
	Disturbance leading to behavioral changes or displacement
	Interference with the use of acoustic communication signals, or naturally-produced cues used by marine animals
	Disruption to feeding, spawning and calving activities of marine fauna

As discussed in *Section 5, Impact Assessment Methodology*, residual impacts have been quantified by assessing the sensitivity of the resources and receptors being impacted, coupled with the magnitude of the impacts, and Anadarko's proposed prevention and mitigation measures to determine the overall impact significance. The overall impact significance is presented for each exploration well drilling activity outlined below, in accordance with *Table 6.2*.

6.3 SOURCE SOUND EMISSIONS

The sound emissions associated with the proposed VSP 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 organisms near to the seismic source during discharge;
- Disturbance leading to behavioral changes or displacement;
- Disruption to feeding, spawning and calving activities of marine fauna such 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.

Potential exists for VSP operations to have an adverse impact on marine mammals. Potential impacts from seismic operations mostly are relevant to 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 likely to occur in the Project Area.

Table 6.3 ***DOC Species of Concern. Source: DOC, 2012***

Latin Name	Common Name	Presence in Project Area
Megaptera novaeangliae	Humpback whale	Possible Presence
Balaenoptera borealis	Sei whale	Possible Presence
Balaenoptera edeni	Bryde's whale	Unlikely to Occur
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	Unlikely to Occur
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	Unlikely to Occur
Hyperoodon planifrons	Southern Bottlenose whale	Unlikely to Occur
Mesoplodon bowdoini	Andrew's beaked whale	Possible Presence
Mesoplodon mirus	True's beaked whale	Possible Presence
Mesoplodon densirostris	Blainville's beaked whale	Possible Presence
Mesoplodon gingkodens	Ginkgo-toothed whale	Unlikely to Occur
Mesoplodon hectori	Hector's beaked whale	Possible Presence
Mesoplodon peruvianus	Pygmy /Peruvian beaked whale	Possible Presence
Tasmacetus shepherdi	Shepherd's beaked whale	Possible Presence

Latin Name	Common Name	Presence in Project Area
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	NZ sea lion	Possible Presence
Tursiops truncatus	Bottlenose dolphin	Possible Presence

Environmental issues relating to VSP are focused on the potential effects on marine fauna from the sound waves associated with the seismic energy source. The pulses associated with VSP 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 VSP events (0 to 130 Hz) 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 kilometers (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 and 0.3 kHz, but pulses also contain some higher frequency energy up to 0.5 to 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 and the duration of the testing. Mobile fauna such as fish and marine mammals will potentially move away from the airgun source at the higher sound levels, thereby reducing their exposure times.

The Project will utilize three sets of air guns, each with a volume of 250 cubic inches, totaling 750 cubic inches. The air guns will be configured in a delta frame and will be powered by either compressed nitrogen gas bottles or by compressor. The guns cluster will be fired at 1,800 psi with shots fired at 20 to 30 seconds at same station and five good shots per station will be stacked. The frequency band for the source sound emission to be used during the VSP is 0 to 130 Hz only with a maximum sound level of 195 dB re 1µPa@1m.

6.3.1 *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 micropascal (µPa) (peak) to cause a permanent loss in hearing ability. High sound levels are found only close to the seismic 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 gender, different activities (foraging, resting, etc.), behavior, individual sensitivities, etc.

As noted in *Section 4.1.4, Marine Mammals*, resident sperm whale habitat distribution has been also reported to lie in the immediate vicinity of the Project Area. 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 did not 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. It is expected that 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, invertebrate and fish gametes and some sessile (i.e. non-mobile) organisms such as marine benthos and some species of fish. The limited number of available studies published 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 potentially occur in other invertebrate larvae species (including coral) due to similar growth patterns.

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*) 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 VSP 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 suggest that the proposed VSP could induce temporary auditory effects on fish near the source, but lasting physiological effects are unlikely.

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 VSP 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 Code requirements as agreed with DOC at all times during VSP activity. Given the small spatiotemporal scale of the Project DOC has agreed to utilize a single MMO and a single PAM operator as opposed to the usual two of each seen in full scale seismic surveys. Specifically, the requirements of the Code will be implemented as follows:

- The drillship will carry at one 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 and the drillship will carry one PAM operator;
- Soft start procedures will be adopted (see *Section 3.3, Environmental Considerations* and *Section 7.3.8, Soft Starts*); and

- 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 any group of Species of Concern (defined in *Section 6.3.4, Disruption to Feeding, Spawning and Calving Activities of Marine Fauna*, below) containing cow-calf pairs are detected within 1.5 km of the survey vessel while survey work is occurring at full power and a shutdown distance of 1 km for all other instances where Species of Concern are detected while the acoustic source is operating at full power, should be applied. For other marine mammal species, start-up procedures should be delayed if presence within 200 m is observed during pre-start.

Further detail relating to the above can be found in *Section 7, Marine Mammal Management plan and The* 2013 *Code Management Measures*, of this MMIA and MMMP.

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

6.3.2 *Behavioral Disturbance Leading To Behavioral Changes or Displacement*

Behavioral responses to seismic activities, 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 seismic activities on whales indicate that VSP 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; seismic noise does not appear to cause changes in the regional migration patterns of cetaceans (McCauley *et al.*, 2003).

Historically, cephalopods (octopuses, squids, and cuttlefishes) were 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 to 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.

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 Code requirements as agreed with DOC at all times during VSP activity. Given the small spatiotemporal scale of the Project DOC has agreed to utilize a single MMO and a single PAM operator as opposed to the usual two of each seen in full scale seismic surveys. Specifically, the requirements of the Code will be implemented as follows:

- The drillship will carry one 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 and the drillship will carry one PAM operator;
- Soft start procedures will be adopted (see *Section 3.3, Environmental Considerations* and *Section 7.3.8, Soft Starts*); and

- 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 any group of Species of Concern (defined in *Section 6.3.4, Disruption to Feeding, Spawning and Calving Activities of Marine Fauna* below) containing cow-calf pairs are detected within 1.5 km of the survey vessel while survey work is occurring at full power and a shutdown distance of 1 km for all other instances where Species of Concern are detected while the acoustic source is operating at full power, should be applied. For other marine mammal species, start-up procedures should be delayed if presence within 200 m is observed during pre-start.

Further detail relating to the above can be found in *Section 7, Marine Mammal Management plan and The 2013 Code Management Measures*, of this MMIA and MMMP.

Residual Impacts

It is anticipated that noise associated with the VSP 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 invertebrate species from VSP noise.

	Residual Impact
Magnitude of impact	Small
Sensitivity of receptor (marine mammals)	Medium
Sensitivity of receptor (invertebrate species)	Low
Significance of impact from VSP noise on marine mammal behavior	Minor
Significance of impact from VSP noise on invertebrate species behavior	Negligible

6.3.3 *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 and communication. Cetaceans emit noise for the purposes of communication and navigation. VSP 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 to 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***

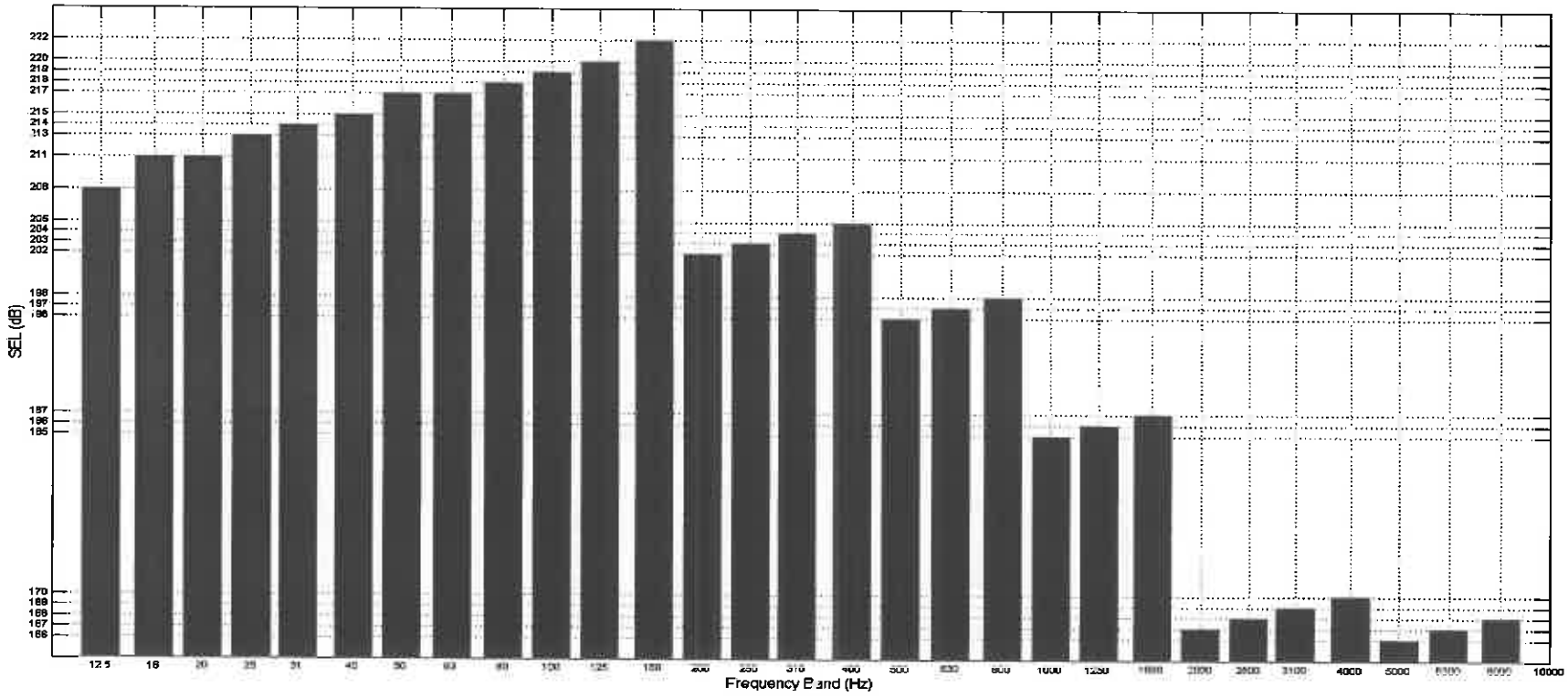
Species	Communication Call Frequency Range (kHz)	Echolocation Frequency Range (kHz)
Bottlenose dolphin	0.8-24	110-130
Common dolphin	0.2-16	23-67
False killer whale	4-30	25-30, 95-130
Killer whale	0.5-25	12-25
Long-finned Pilot whale	1-18	6-117
Sperm whale	0.1-30	2-30
Blue whale	0.018-0.1	0.01-0.4

There is good evidence to suggest that baleen whales are particularly susceptible to disturbance from seismic activities. 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 VSP. Although potentially disrupting normal behavior, this will ultimately limit their exposure to the seismic source and reduce the risk of physiological effects.

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 VSP.

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



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. In addition, marine mammals are likely to practice avoidance techniques during VSP, further limiting their exposure to seismic sources.

As per Section 5.3 of this MMIA *"An impact is significant if, in isolation or in combination with other impacts, it should in the judgment of the MMIA team be taken into account in the decision-making process, including the identification of mitigation measures and potential consenting conditions."* Within any impact assessment, there is a continuum of significance. To identify where in this continuum an impact applies, ERM applies a globally, and nationally, recognised impact assessment methodology.

The magnitude of the impact and sensitivity of receptors are determined through the criteria stipulated in the methodology section of this MMIA. As such, the magnitude of this 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. The fits with the criteria as stipulated in the method section of this MMIA, which stipulates that an ecological impact is of small magnitude when *"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."*

The sensitivity of marine mammals is considered to be ***medium*** as *"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."*

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 Code requirements as agreed with DOC at all times during VSP activity. Given the small spatiotemporal scale of the Project DOC has agreed to utilize a single MMO and a single PAM operator as opposed to the usual two of each seen in full scale seismic surveys. Specifically, the requirements of the Code will be implemented as follows:

- The drillship will carry one independently trained MMO for the duration of the survey;
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- Soft start procedures will be adopted (see *Section 3.3, Environmental Considerations* and *Section 7.3.8, Soft Starts*); and

- 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 any group of Species of Concern (defined in *Section 6.3.4, Disruption to Feeding, Spawning and Calving Activities of Marine Fauna*, below) containing cow-calf pairs are detected within 1.5 km of the survey vessel while survey work is occurring at full power and a shutdown distance of 1 km for all other instances where Species of Concern are detected while the acoustic source is operating at full power, should be applied. For other marine mammal species, start-up procedures should be delayed if presence within 200 m is observed during pre-start.

Further detail relating to the above can be found in *Section 7, Marine Mammal Management plan and The 2013 Code Management Measures*, of this MMIA and MMMP.

Residual Impacts

Considering the above mitigation measures, including soft-starts and the use of PAM/MMOs, VSP 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 VSP noise on marine mammal communication	Minor

6.3.4 *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	NA	Late June to mid-September	NA
Jack mackerel	NA	Spring and summer	NA
Ling	NA	Spring through to summer	NA
Squid	NA	Winter typically June and July	NA
Oreo (smooth)	NA	late October to at least December	NA
Hake	NA	June to September	NA
Orange roughy	NA	between June and early August	NA
Southern blue whiting	NA	generally is August-October	NA
Sperm whales	Year round	Year round	Winter
Pygmy sperm whale	Year round+	No data	-

Species	Feeding	Spawning/Calving	Migration
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+	-
Southern right whale	Summer	Winter	-
Pygmy right whale	Year round	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	-

* Seven species of beaked whale are included in the Code.
+ Based on limited data for these species.

Although a number of marine mammals listed as species of concern in the Code could be present in the Project Area during VSP activities, potential effects would be primarily related to the disturbance of feeding activities (Stephens and Krebbs, 1986). 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.

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 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.

The magnitude of impact from VSP on the important life stages of marine fauna is therefore considered to be negligible, given the schedule of the proposed VSP and the wide distribution of the commercially important fish species and listed marine mammals above. Impacts are considered 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.

Mitigation Measures

The Code requires a larger mitigation area for mother-calf pairs which will be implemented during the survey. Further, the timing of the proposed VSP program (summer), will not coincide with important biological periods identified for the above listed marine mammals. The short duration of the activity and 24/7 operations to minimize the overall duration of the survey will also be minimize exposure to any residual impacts.

Residual Impacts

Given the short duration of the VSP program and the timing which will not coincide with important biological periods of listed marine mammals, the VSP is likely to have a ***negligible*** effect on the basic life histories of these species.

The VSP 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 VSP on the basic life history of marine mammals	Negligible
Significance of impact from VSP on the basic life history of commercially important fish species	Negligible

7 MARINE MAMMAL MANAGEMENT PLAN AND THE 2013 CODE MANAGEMENT MEASURES

Table 7.1 summarizes the project activities, associated impacts, and impact mechanisms identified in this assessment. Under the 2013 Code, the Project is classified as Level 1. The requirements of a Level 1 Survey as set out under the Code are described subsequently in *Section 7.1, Level One Survey Requirements, Section 7.2, Marine Mammal Observer and Passive Acoustic Monitor Operator Training and Experience* and *Section 7.3, Operational Detailed Requirements.*

Table 7.1 VSP 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					
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. Adherence with the Code, specifically: • Use of MMO; • Use of PAM; • Use of soft start procedures; • Stop work procedures; and • 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

7.1 LEVEL ONE SURVEY REQUIREMENTS

7.1.1 *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 and MMMP fulfils this requirement.

7.1.2 *Observer Requirements*

Anadarko will adhere to the Code requirements as agreed with DOC at all times during VSP activity. Given the small spatiotemporal scale of the Project DOC has agreed to utilize a single MMO and a single PAM operator as opposed to the usual two of each seen in full scale seismic surveys.

The minimum qualified observer requirements will be:

- 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;
- MMO maintains 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.

7.1.3 *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 *Section 7.1.4, Delayed starts and shutdowns*, below.

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

- PAM 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

- MMO has 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.

7.1.4 Delayed starts and shutdowns

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

If, during pre-start observations or while 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:

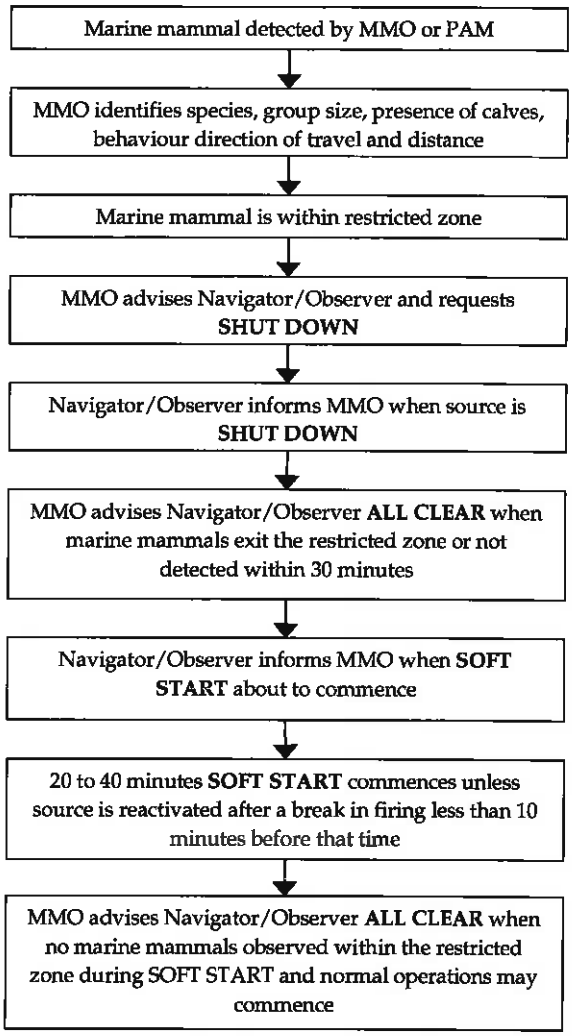
- A qualified observer confirms the marine mammal has moved to a point that is more than 200 m from the source; or
- Despite continuous observation, 10 minutes has passed since the last detection of a NZ fur seal within 200 m of the source and 30 minutes has elapsed since the last detection of any other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

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.

7.1.5 *Communications Flow*

When marine mammals are observed within the restricted zone, the PAM operator and MMO will liaise directly with the relevant seismic survey personnel (usually the seismic navigator or observer) to notify them of the sighting and any requirements for shut down of the seismic source. *Figure 7.1* summarizes the communications process between the MMO and survey personnel in the event of marine mammal sightings. MMO duties with regards notification of DOC, eg in the event that any instances of non-compliance with the Code and/or higher numbers of cetaceans/Species of Concern are encountered are presented in *Section 7.3.2, Marine Mammal Observer Duties.*

Figure 7.1 Communication Flow



7.2 *MARINE MAMMAL OBSERVER AND PASSIVE ACOUSTIC MONITOR OPERATOR TRAINING AND EXPERIENCE*

Prior to commencing the Survey, the MMO and PAM operator 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 drillship or support 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.

7.3 *OPERATIONAL DETAILED REQUIREMENTS*

7.3.1 *Observer Effort*

The one MMO on board during the VSP activity will be on watch during daylight hours while the acoustic source is in the water in the operational area. The one PAM operator also on board during the VSP activity 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 VSP activities.

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, the qualified MMO will be on watch during pre-start observations during daylight hours, or at any other key times where practical and possible.

If the MMO has adequate understanding of the PAM system in operation and 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 7.3.10, Recording and Reporting Requirements.*

7.3.2 *Marine Mammal Observer Duties*

While acting in their designated role, the MMO 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 drillship 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 and concurrently with Anadarko to clarify any uncertainty or ambiguity in application of the Code;
- Record and report any instances of non-compliance with the Code immediately; and
- Notify the Director-General immediately and concurrently with Anadarko 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.

7.3.3 *Passive Acoustic Monitor Operator Duties*

While acting in their designated role, the PAM operator 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 and concurrently with Anadarko, to clarify any uncertainty or ambiguity in application of the Code; and
- Record and report any instances of non-compliance with the Code.

7.3.4 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 MMMP.

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'.

7.3.5 *Observer Deployment*

The preference for operational deployment of observers is on the drillship. However, if there are critical operational constraints in positioning observation teams on the drillship, they may be redeployed onto the support vessel providing that their ability to perform in their specific roles is not compromised and they will remain in direct communications with the drillship. 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.

7.3.6 *Crew Observations*

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

In the event that the MMO is not able to view the animal, they will provide a sighting form to the crew member and instruct 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 the MMO within the reports.

7.3.7 *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.

7.3.8 *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.

Repeated 10-minute break exceptions from soft start requirements by sporadic activation of acoustic sources at full or reduced power within that time, will not occur.

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.

7.3.9 *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.

7.3.10 *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 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.

The Director-General will be informed immediately and concurrently with Anadarko if the qualified observers consider that higher numbers of cetaceans and/or Species of Concern than predicted in the MMIA and MMMP 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.

It is noted that unlike Maui's dolphin sighting, DOC does not require immediate contact for Hector's dolphin sightings. However, for background information, the best point of contacts for Hector's dolphin sightings in the Canterbury and Otago regions are: DOC Akaroa Field Base, Canterbury (Derek Cox, dcox@doc.govt.nz, ;
and DOC Coastal Otago District Office (Jim Fyfe, jfyfe@doc.govt.nz ,

The Director-General will be informed immediately about any instances of non-compliance with the Code.

7.3.11 *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 Department of Conservation website at http://www.doc.govt.nz/notifications.

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Annex A

Stakeholder Engagement Register

Stakeholder	Engagement Activities	Existing Interests? (Yes/No)
Regulators and Government Agencies		
Environmental Protection Agency	• **4/5/12** Meeting with to discuss iwi engagement programme, arrange briefing for Nga Kaihautu. • **21/9/12** Meeting with Nga Kaihautu – overview of exploration programme; discussion regarding iwi engagement. • **16/1/13** Meeting with regarding iwi engagement. • Various Ongoing meetings with EPA staff in the preparation of Canterbury and Taranaki EIA	No
NZ Petroleum and Minerals	• **31/1/13** Meeting with regarding iwi engagement – work to date and future plans • **28/3/13** Meeting with regarding iwi engagement (follow up to earlier meeting) • **10/6/13** Meeting regarding application for a non-interference zone • **23/8/13** Meeting regarding application for a non-interference zone	No
Maritime NZ	• **Jan 2011** Meeting with Marine Pollution Response Service – introducing Anadarko • **May 2011** Meeting with Rescue Coordination Centre • **28/2/12** Meeting with Maritime NZ (who and regarding what) • Various Ongoing meetings with Maritime NZ staff in the preparation of Discharge Management Plan	No
Department of Conservation	• **Feb 2012** Meeting with DOC business partnerships group • **13/8/13** Letter regarding seismic acquisition in the Pegasus Basin • Various Ongoing meetings with EPA staff regarding exploration activities	No
Department of Labour	• **Jan 2011** Introductory meeting • **2/3/2012** Meeting with High Hazards Unit, to provide overview of Anadarko's plans and discuss safety case requirements. • **6/5/13** Meeting with and to discuss safety case	No

Biosecurity NZ	• **29/2/12** Meeting with Biosecurity NZ regarding biosecurity requirements • **15/5/12** Meeting with regarding biosecurity requirements • **18/9/12** Meeting with to provide an update on Anadarko activities • **26/4/13** Meeting with to provide update, discuss requirements.	No
Iwi, hapu and runaka		
Ngai Tahu [1]	• **9/11/11** Introductory briefing for (Ngai Tahu offices, Wigram). • **14/5/12** Meeting with to provide update on activities. • **25/2/13** Meeting with (Kai Tahu Ki Otakau) to initiate work towards a Cultural Impact Assessment. • **5/6/13** Meeting with (Natural Resources Manager, Te Runanga o Ngai Tahu) • **27/6/13** Draft EIA provided to KTKO to inform Cultural Impact Assessment	Yes - customary fishing and food gathering - recreational
Kati Huirapa	• **17/7/12** Introductory briefing for Discussion regarding organization of hui. • **23/9/12** Hui – six Anadarko representatives in attendance; 20 iwi members. Presentations on New Zealand operations and Environmental Health and Safety . Extensive Q and A session. • **24/9/12** Representatives invited to attend community leaders function in Dunedin. • **13/7/13** Representatives invited to attend presentation on deepsea drilling in Dunedin.	Yes - customary fishing and food gathering
Otakou	• **4/12/11** Hui at Otakau Marae. Presentations on New Zealand operations and Environmental Health and Safety followed by extensive Q and A session. Attended by 30-40 iwi representatives. • **24/9/12** Representatives invited to attend community leaders function in Dunedin. • 13/7/13 Representatives invited to attend presentation on deepsea drilling in Dunedin.	Yes - customary fishing and food gathering - recreational

[1] Anadarko New Zealand has conducted additional, regular engagement with Ngai Tahu leaders following the company being awarded two new exploration permits in the Pegasus Basin (December 2012).

Moeraki	• 4/5/13 Hui at Moeraki Marae. Introductory presentations by (Exploration Manager) and (Environmental Health and Safety Manager). • 13/7/13 Representatives invited to attend presentation on deepsea drilling in Dunedin.	Yes - customary fishing and food gathering - recreational
Fishing Interests		
Seafood Industry Council	• 5/10/12 Meeting with Chief Executive • 1/9/13 Meeting with Chief Executive	Yes - comm. fisheries
Deepwater Group, Seafood New Zealand	• 11/10/12 Meeting with Chief Executive	Yes - comm. fisheries
Te Ohu Kaimoana	• 11/10/12 Meeting with Chief Executive • 12/2/13 Meeting with Chairman	Yes - comm. fisheries
Independent Fisheries	• 16/9/13 Meeting with Board of Directors	Yes - comm. fisheries
Ngai Tahu Fisheries	• No meetings to date	Yes - comm. fisheries
Local body representatives		
Dunedin City Council		Yes - local community
Otago Regional Council	• 18/4/13 Meeting with Chief Executive and Chair	Yes - local community
Waitaki	• 10/5/12 Meeting with Mayor	Yes - local community
Timaru	• 10/5/12 Meeting with Mayor	Yes - local community

Aoraki Development Board	• **10/5/12 –** Meeting with Chief Executive	Yes - local community
Christchurch City Council	• **30/8/12** Meeting with Mayor	**Yes** - local community

Annex B

Passive Acoustic Monitoring System

Specifications of the PAM equipment

Hardware

Blue Planet Marine can provide various customised passive acoustic monitoring systems suitable for detecting and monitoring cetaceans during seismic survey. The full specifications of this system are not included in this document, however can be supplied on request

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

The variety of cetacean species likely to be encountered during seismic survey mitigation produce vocalisations over an extremely broad frequency range, from the infrasonic 15-30Hz calls of large baleen whales to the 130kHz pulses of harbour porpoise and Hectors dolphin. To be able to capture all of these, while reducing unwanted noise the PAM system uses two different hydrophone/premp pairs with widely overlapping frequency sensitivity: a low/medium frequency pair and a high frequency pair. These hydrophone pairs can be monitored, filtered and sampled independently.

Filtering and amplification hardware is custom-built by *Magrec* to meet the specification required for cetacean monitoring. Important features include: adjustable low frequency filters from 0Hz to 3.2kHzs which can be applied to reduce low frequency noise allowing the available dynamic range to be conserved for capturing marine mammal vocalisations within the frequency bands used each species. The Magrec preamp also provides an output with a fixed 20kHz low cut filter to optimise detection of the very high frequency vocalisations of porpoise, Hectors dolphins, beaked whales and Kogia. Additional, highly configurable digital band-pass and band-stop filtering is provided by on-board signal processing within the specialised USB sound card.

Audio and low-ultrasonic frequency bands (up to 96 kHz) are digitised using a USB sound card. Ultra high frequency click detection (which is particularly useful for porpoise, Hector's dolphins, kogia etc) is achieved by using a National Instruments Digital Acquisition card with a sampling rate of 1.2 mega samples s^{-1}.

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

Software

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

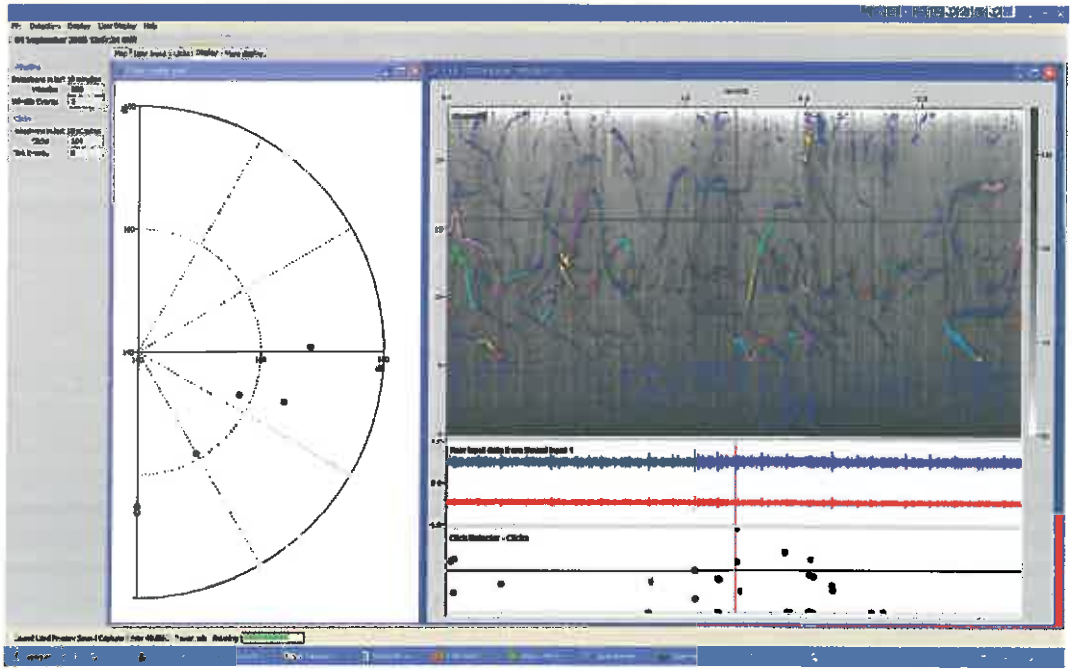
PAMGUARD is an extremely flexible program with a range of modules that can be combined to provide customised configurations to suit particular applications. It includes modules for detecting both transient vocalisations (clicks) and tonal calls (e.g. whistles and moans). Cetacean click

vocalisations range from the medium frequency clicks of sperm whales that can be detected at ranges of several miles, through the powerful broadband clicks produced by most delphinids to the specialised narrow band pulses of beaked whales, harbour porpoises and Hector's dolphins. High frequency tonal sounds include the whistle vocalisations produced by delphinids while low frequency tonals are produced by baleen whales. When data from two or more hydrophone elements are available PAMGUARD can calculate bearings to these vocalizations and provide locations by target motion analysis.

PAMGUARD also includes routines for measuring and removing background noise, and for vetoing particularly intense sounds such as Airgun pules.

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

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



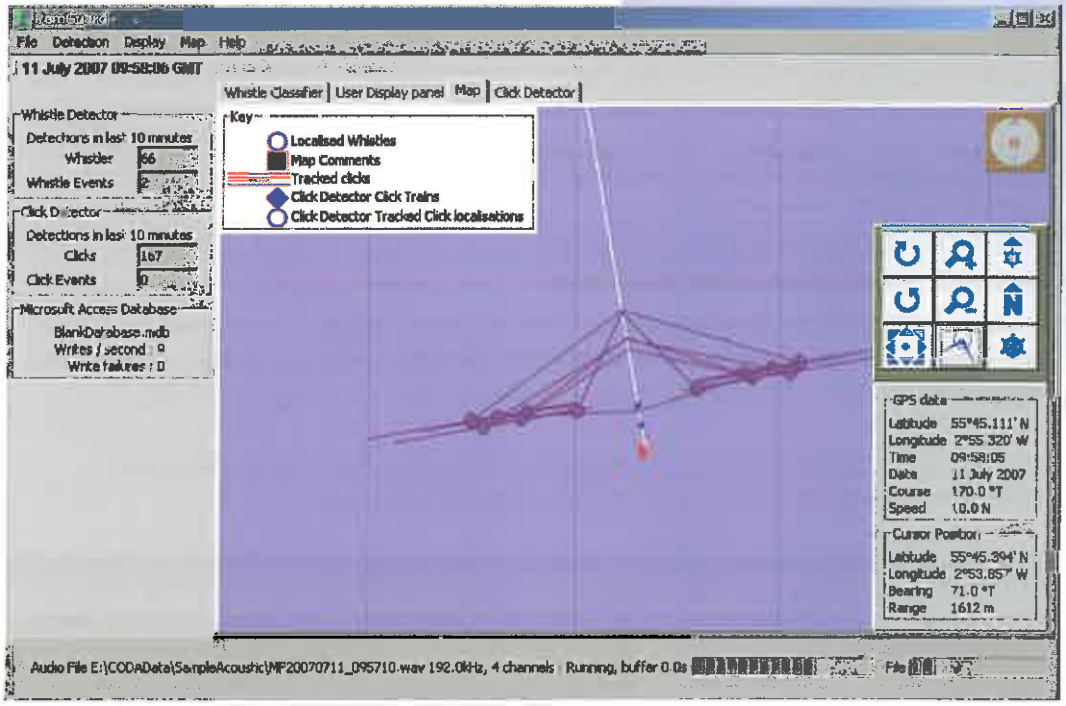


Figure 1 Screen shot from PAMGUARD Whistle and Click Detection and Mapping and Localisation Modules typical of a Seismic Mitigation configuration

Species Detection

The frequency range, call type and vocal behaviour of cetaceans varies enormously between species and this affects the degree to which PAM provides additional detection power, especially in the noisy environment of a seismic survey. This system has proven very effective in detecting small odontocetes and sperm whales, increasing detection reliability by an order of magnitude during trials (funded by Shell) conducted off the UK. PAM is particularly effective for the detection of sperm whales as they can be heard at significant ranges (several miles) and are consistently vocal for a large proportion of the time. Smaller odontocetes such as dolphins, killer whales, pilot whales and other "black fish" can be detected at useful ranges from both their whistle and click vocalisations but they often move so quickly that target motion may be difficult. The effective range for harbour porpoise (~400 m) is limited by the high rate of absorption of their ultra high frequency clicks. This is usually within proscribed mitigation ranges so that any reliable detection should lead to action. Towed hydrophones of this type have been very effective in picking up vocalisations from beaked whales during surveys and the narrow bandwidth and characteristic upsweep in their clicks greatly assists with their classification. However, beaked whales clicks are highly directional and vocal output can be sparse and intermittent so overall detection probability may remain low.

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

Standard Seismic Mitigation Acoustic Monitoring System

Towed Hydrophone	
Acoustic Channels	2 x Medium Frequency Benthos AQ4. –201 dBV re 1µPa (+/- 1.5 dB 1-15kHz) with Magrec HP02 broad band preamps (LF cut filter @ 100Hz or 50Hz as required) Near-flat Sensitivity 50Hz- 15kHz with good sensitivity to higher frequencies 2 x High Frequency Magrec HP03 units, comprising a spherical ceramic and HP02 preamp (Low cut filter set at 2kHz) Near flat sensitivity 2kHz- 150kHz +/-6 dB 500Hz to 180kHz
Depth Sensor	Keller 4-20Ma 100m range Automatically read and displayed within PAMUARD
Streamlined housing	5m, 3 cm diameter polyurethane tube. Filled with Isopar M.
Cable	340m multiple screened twisted pair, with strain relief and Kellum's grip towing eye, Length deployed may vary to suit application
Connectors	19 pin Ceep IP68 waterproof
Deck cable	~75m 19pin Ceep to breakout box
Topside Amplifier Filter Unit	
Unit	Magrec HP27ST
Supply Voltage	10-35 V DC
Supply current	200mA at 12 V
Input	Balanced input
Gain	0,10,20,30,40,50 dB
High Pass Filter	-6db/octave selectable 0, 40, 80, 400,1.6k, 3.2k
Output	2 X Balanced output via 3 pin XLR
Ultra HF Output	2 X Balanced output via 3 pin XLR (with 20kHz high pass filter for porpoise detection)
Headphone	Dual output via ¼" jack
Overall Bandwidth	10Hz-200kHz +/–3dB
GPS	
Input	Serial to USB adapter to interface with ship's NMEA supply
Backup	Standalone USB unit provided as independent backup
Computers	
	Up to date Laptop Computers
Digitisers	
Digitiser	NI USB 6251 high speed Digital Acquisition (if required for porpoise detection)
Sound Card	High quality sound card 192kHz sampling rate e.g. Motu Ultralite Mk3 Hybrid, Or RME Fireface 400
Software	
General	PAMGUARD with appropriate configurations
Porpoise Detection	Rainbow Click / Logger

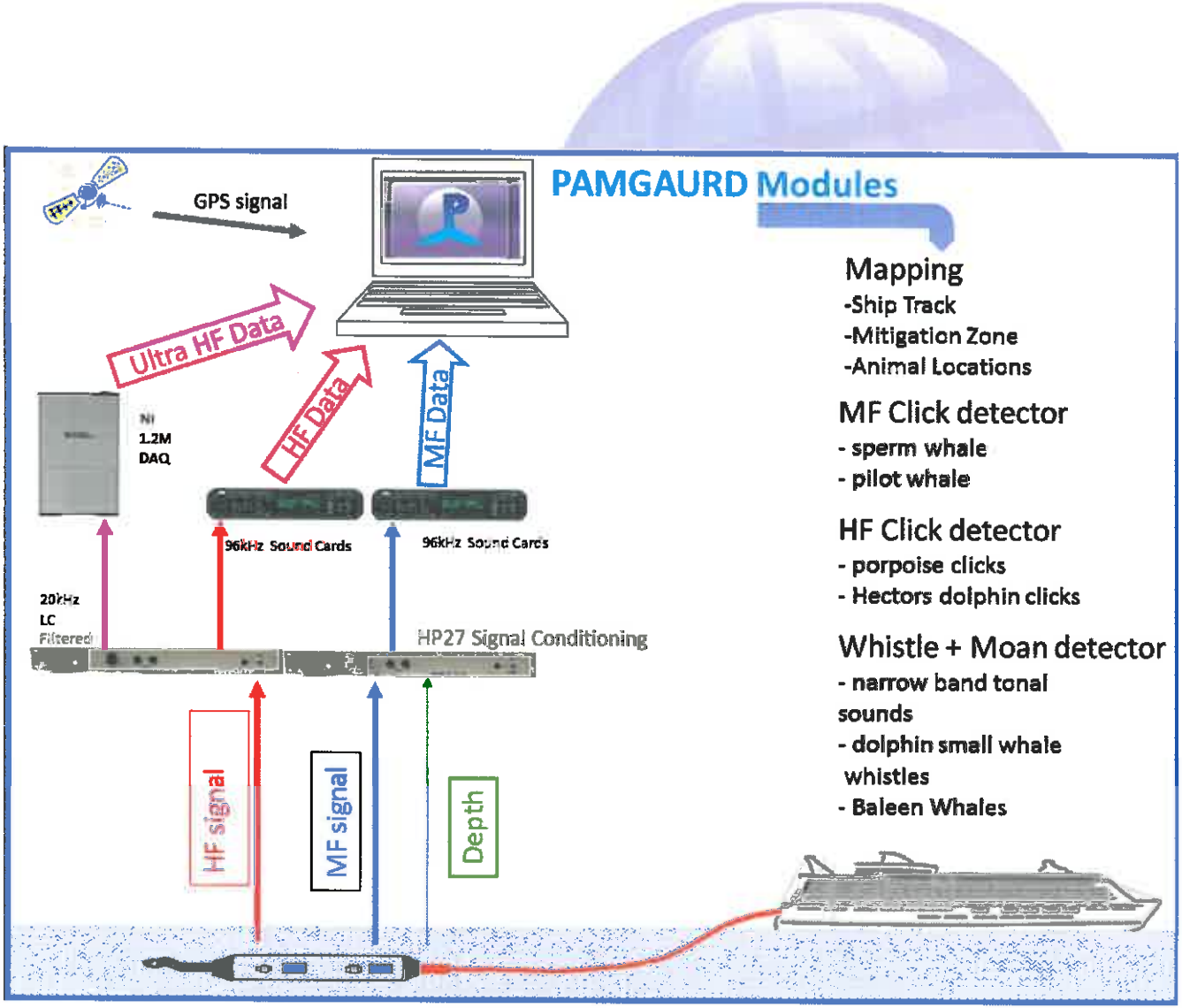


Figure 2. Schematic representation of BPM Multi-Channel PAM system.

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