Draft Environmental Analysis of a Low-Energy Marine Geophysical Survey by the R/V *Roger Revelle* in the Southwest Pacific Ocean, East of New Zealand, May–June 2015

Prepared for

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ABSTRACT

The Scripps Institution of Oceanography (SIO) plans to support a research activity that would involve low-energy seismic surveys, coring, and heat-flow measurements at three sites off the east coast of New Zealand in May–June 2015. The research activity would be funded by the U.S National Science Foundation (NSF). The seismic survey would use a pair of low-energy Generator-Injector (GI) airguns with a total discharge volume of ~90 in^3. The seismic survey would take place in water depths 200–3000 m within the Exclusive Economic Zone (EEZ) and outside of the territorial waters of New Zealand. On behalf of SIO, the U.S. State Department will seek authorization from New Zealand for clearance to work within the EEZ.

NSF, as the funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed survey would collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as a NSF program priority. It would allow the development of a process-based understanding of the thermal structure of the Hikurangi subduction zone, and the expansion of this understanding by using regional observations of gas hydrate-related bottom-simulating reflections.

The Draft Environmental Analysis (EA) in this document addresses NSF's requirements under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", for the proposed NSF federal action. SIO is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental, i.e., not intentional, harassment of small numbers of marine mammals should this occur during the seismic survey. The issue regarding whether the Marine Mammal Protection Act (MMPA) applies to U.S. activities occurring within the EEZ of foreign States remains unsettled as a matter of law. Therefore, the submission of the IHA application to NMFS does not constitute a waiver or adoption of any position regarding that issue. The analysis in this document also supports the IHA application process and provides information on marine species that are not addressed by the IHA application, including seabirds and sea turtles that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/threatened species was included, this document will be used to support ESA Section 7 consultations with NMFS and U.S. Fish and Wildlife Service (USFWS). Alternatives addressed in this Draft EA consist of a corresponding program at a different time with issuance of an associated IHA and the no action alternative, with no IHA and no seismic survey. This document tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF-USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS.

Numerous species of marine mammals inhabit the waters of New Zealand. Several of these species are listed as ***endangered*** under the U.S. Endangered Species Act (ESA): the southern right, sperm, humpback, sei, fin, and blue whales. Other species listed as ***endangered*** under the ESA that are known to occur in New Zealand include the leatherback, hawksbill, and loggerhead sea turtles (South Pacific Distinct Population Segment), the Chatham and magenta petrels, the New Zealand shore plover, and the black stilt. The ***threatened*** green and olive ridley turtles, and five ***threatened*** penguin species (yellow-eyed, white-flippered, Fiordland crested, erect-crested, and rock hopper penguin) are also known to occur in the waters of New Zealand.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the pair of GI airguns. A multibeam echosounder and a sub-bottom profiler would also be

operated. Impacts would be associated with increased underwater noise, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to minimize potential impacts of the proposed activities on marine animals present during the proposed research, and to document as much as possible the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airguns including high-energy airgun arrays, and also are not likely to be caused by the other types of sound sources to be used. However, despite the relatively low levels of sound emitted by a pair of GI airguns, a precautionary approach would still be taken. The planned monitoring and mitigation measures would reduce the possibility of injurious effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals and sea turtles would include the following: ramp ups; typically two, but a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers 30 min before and during ramp ups during the day; no start ups during poor visibility or at night unless at least one airgun has been operating; and shut downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. SIO and its contractors are committed to applying these measures in order to minimize effects on marine mammals and sea turtles and other environmental impacts.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals may be interpreted as falling within the U.S. MMPA definition of "Level B Harassment" for those species managed by NMFS. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, the populations to which they belong, or their habitats.

LIST OF ACRONYMS

~	approximately
AMVER	Automated Mutual-Assistance Vessel Rescue
BSR	Bottom Simulating Reflector
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
dB	decibel
DPS	Distinct Population Segment
EA	Environmental Analysis
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
FM	Frequency-Modulated
GeoPRISMS	Geodynamic Processes at Rifting and Subducting Margins
GI	Generator-Injector
GIS	Geographic Information System
h	hour
hp	horsepower
Hz	Hertz
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
IODP	International Ocean Discovery Program
ISRP	Independent Scientific Review Panel
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer
KMMA	Kaikōura Marine Management Area
kt	knot
L-DEO	Lamont-Doherty Earth Observatory of Columbia University
LFA	Low-Frequency Active (Sonar)
m	meter
MBES	multibeam echosounder
MCS	multi-channel seismic
MFA	Mid-Frequency Active (Sonar)
min	minute
MMPA	(U.S.) Marine Mammal Protection Act
MPA	Marine Protected Area
MPI	(New Zealand) Ministry for Primary Industries
ms	millisecond
M/V	motor vessel
n.mi.	nautical mile
NABIS	(New Zealand) National Aquatic Biodiversity Information System

NEPA	(U.S.) National Environmental Policy Act
NMFS	(U.S.) National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NRC	(U.S.) National Research Council
NSF	National Science Foundation
NZ	New Zealand
NZDOC	New Zealand Department of Conservation
OAWRS	Ocean Acoustic Waveguide Remote Sensing
OBIS	Ocean Biogeographic Information System
OBS	Ocean Bottom Seismograph
OEIS	Overseas Environmental Impact Statement
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
PSVO	Protected Species Visual Observer
QAA	Qualitative Analysis Area
RL	Received level
rms	root-mean-square
R/V	research vessel
s	second
SAUP	Sea Around Us Project
SBP	Sub-Bottom Profiler
SEL	Sound Exposure Level
SIO	Scripps Institution of Oceanography
SPL	Sound Pressure Level
SST	Sea Surface Temperature
SSTC	South Subtropical Convergence Province
TTS	Temporary Threshold Shift
UNEP	United Nations Environment Programme
U.S.	United States of America
USC	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USIO	U.S. Implementing Organization
USN	U.S. Navy
µPa	microPascal
vs.	versus

I. PURPOSE AND NEED

The purpose of this Environmental Analysis (EA) is to provide the information needed to assess the potential environmental impacts associated with the use of a pair of 45-in^3 Generator-Injector (GI) airguns, heat flow measurements, and sediment coring during the proposed surveys. The EA was prepared under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions". This EA tiers to the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The EA addresses potential impacts of the proposed seismic surveys on marine mammals, as well as other species of concern in the area, including sea turtles, seabirds, fish, and invertebrates. The EA will also be used in support of an application submitted by SIO for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) and NSF's Section 7 consultations under the Endangered Species Act (ESA). The requested IHA would, if issued, allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals during the proposed seismic surveys by SIO off eastern New Zealand during May–June 2015. The issue regarding whether the Marine Mammal Protection Act (MMPA) applies to U.S. activities occurring within the Exclusive Economic Zones (EEZ) of foreign States remains unsettled as a matter of law. Therefore, the submission of the IHA application to NMFS does not constitute a waiver or adoption of any position regarding that issue.

To be eligible for an IHA under the U.S. MMPA, the proposed "taking" (with mitigation measures in place) must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must "take" no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses.

Mission of NSF

The National Science Foundation (NSF) was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. Further details on the mission of NSF are described in § 1.2 of the PEIS.

Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. High-resolution multi-channel seismic (MCS) profiles, heat-flow measurements, and sediment cores would be collected off the northern and southern Hikurangi margin off the southeast coast of North Island and northeast coast of South Island, New Zealand. The proposed study would use the resulting sediment seismic velocities, heat-flow values, and data from sediment cores to develop a process-based understanding of the thermal structure of the Hikurangi subduction zone; data from sediment cores would detect and estimate the nature and sources of fluid flow through high permeability pathways in the overriding plate and incoming plate, and along the subduction thrust, characterize the hydrocarbon and gas hydrate system to assist with estimates of heat flow from bottom simulating reflectors (BSRs), their role in slope stability, and fluid source, and elucidate the response of microbes involved in carbon cycling to changes in methane flux. This understanding would be expanded by using regional observations of gas hydrate-related

BSRs. The area of the northern Hikurangi margin is underlain by an aseismic creep-dominated subduction interface and is the site of repeated shallow (<15 km depth) slow-slip earthquakes, whereas the slow-slip earthquakes at the southern Hikurangi margin are deep (>30 km), and geodetic studies indicate updip interseismic coupling on the plate interface. Heat-flow measurements would be made in well-characterized sites, increasing the number of publicly available heat-flow measurements from this continental margin by two orders of magnitude. The proposed low-energy seismic, heat-flow, and coring activities would continue to meet NSF's critical need to foster a better understanding of Earth processes.

Background of NSF-funded Marine Seismic Research

The background of NSF-funded marine seismic research is described in § 1.5 of the PEIS.

Regulatory Setting

The regulatory setting of this EA is described in § 1.8 of the PEIS, including

- Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions";
- Marine Mammal Protection Act (MMPA); and
- Endangered Species Act (ESA).

II. ALTERNATIVES INCLUDING PROPOSED ACTION

In this EA, three alternatives are evaluated: (1) the proposed seismic surveys and issuance of an associated IHA, (2) corresponding seismic surveys at an alternative time, along with issuance of an associated IHA, and (3) no action alternative. Additionally, two Alternatives were considered but were eliminated from further analysis. A summary table of the proposed action, alternatives, and alternatives eliminated from further analysis is provided at the end of this section.

Proposed Action

The project objectives and context, activities, and mitigation measures for SIO's planned seismic surveys are described in the following subsections.

(1) Project Objectives and Context

SIO plans to conduct low-energy seismic surveys, heat-flow measurements, and sediment coring at three sites off the southeast coast of North Island and northeast coast of South Island, New Zealand (Fig. 1). The proposed surveys would allow the development of a process-based understanding of the thermal structure of the Hikurangi subduction zone, and the expansion of this understanding by using regional observations of gas hydrate-related bottom-simulating reflections. To achieve the project's goals, the Principal Investigators (PIs), Drs. R.N. Harris and A. Tréhu (Oregon State University), propose to collect low-energy, high-resolution MCS profiles, heat-flow measurements, and sediment cores along transects seaward and landward of the Hikurangi deformation front. As noted previously, heat-flow measurements would be made in well-characterized sites, increasing the number of publicly available heat-flow and thermal conductivity measurements from this continental margin by two orders of magnitude. Seismic survey data would be used to produce sediment structural maps and seismic velocities to achieve the project objectives. Data from sediment cores would detect and estimate the nature and sources of fluid flow through high permeability pathways in the overriding plate and along the subduction thrust; characterize the hydrocarbon and gas hydrate system to assist with estimates of heat flow from BSRs, their role in slope stability, and fluid source; and elucidate the response of microbes involved in carbon cycling to changes in methane flux.

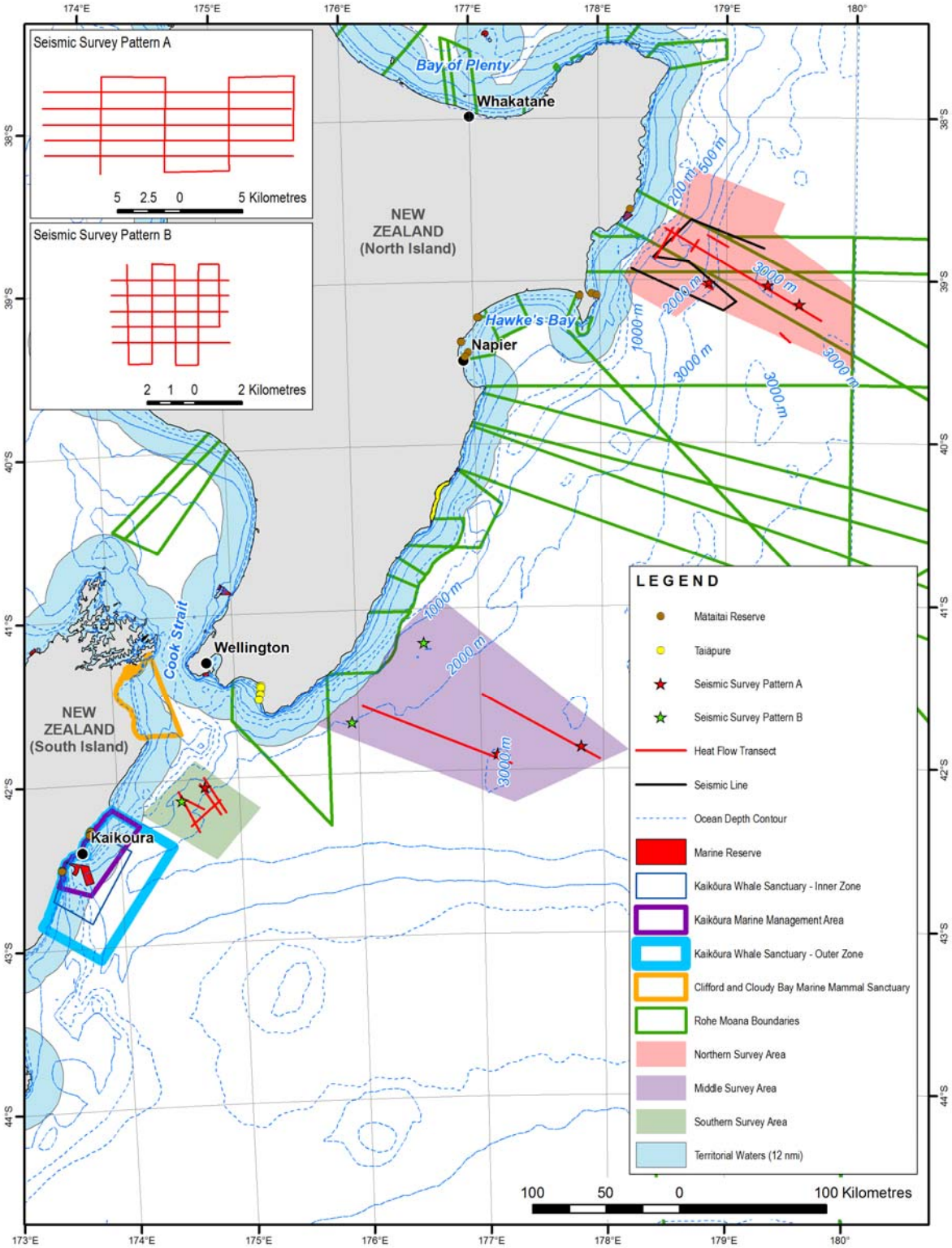

FIGURE 1. Locations of the proposed low-energy seismic surveys and heat-flow measurement sites east of New Zealand, May–June 2015, and marine protected areas in the survey area.

(2) Proposed Activities

(a) Location of the Activities

The proposed survey sites are located between ~38.5°–42.5°S and ~174–180°E off the east coast of New Zealand (Fig. 1). Water depths in the survey area are ~200–3000 m. The seismic surveys would be conducted in the EEZ of New Zealand, outside of territorial waters.

(b) Description of the Activities

The procedures to be used for the seismic surveys would be similar to those used during previous seismic surveys by SIO and would use conventional seismic methodology. The surveys would involve one source vessel, the R/V *Roger Revelle (Revelle)*. The *Revelle* would deploy a pair of 45-in^3 GI airguns as an energy source with a total volume of ~90 in^3. The receiving system would consist of one 600-m hydrophone streamer. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system. Seismic surveys would be conducted while the heat-flow probe (see below) is being recharged.

Seismic surveys would be collected in a total of nine grids of intersecting lines of two sizes (see Fig. 1) at exact locations to be determined in the field. The water depths would be very similar to those at the nominal survey locations shown in Figure 1. The northern and middle sites off North Island are the primary study areas, and the southern site off South Island is a contingency area that would only be surveyed if time permits. Our calculations assume that seven grids at the primary areas and two grids at the southern site would be surveyed. The total track distance of the surveys would be ~1250 km, almost all (95%) in water depths >1000 m.

There would be additional seismic operations in the survey area associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard. In our calculations [see § IV(3)], 25% has been added for those additional operations.

Heat-flow measurements would be made using a "violin-bow" probe, 3.5 m long with 11 thermistors, that provides real time (analog) telemetry of the thermal gradient and in-situ thermal conductivity. Internal power allows 20–24 measurements during a single lowering of the tool, with profiles lasting as long as 48 h. Heat-flow measurements would have a nominal spacing of 0.5–1 km, which would be decreased in areas of significant basement relief or of large changes in gradient. Heat-flow transect locations are shown in Figure 1, and details of the probe and its deployment are given in Section (f) below. In total, ~200 heat-flow measurements would be made.

Details of the coring devices and their deployment are given below in Section (g). Sediment cores would be collected at ~20 locations, mostly in the northern survey area.

In addition to the operations of the airgun array, heat-flow measurements, and coring, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the *Revelle* continuously throughout the cruise. All planned data acquisition and sampling activities would be conducted by SIO with on-board assistance by the scientists who have proposed the study. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

(c) Schedule

The *Revelle* would depart from Auckland, New Zealand, on 18 May 2015 and return to Napier, New Zealand, on 18 June 2015. Seismic operations would take ~135 h in total, and the remainder of the time would be spent in transit and collecting heat-flow measurements and cores.

(d) Vessel Specifications

The *Revelle* has a length of 83 m, a beam of 16.0 m, and a maximum draft of 5.2 m. The ship is powered by two 3000-hp Propulsion General Electric motors and a 1180-hp azimuthing jet bow thruster. An operation speed of 9.3 km/h (5 kt) would be used during seismic acquisition. When not towing seismic survey gear, the *Revelle* cruises at 22.2–23.1 km/h (12–12.5 kt) and has a maximum speed of 27.8 km/h (15 kt). It has a normal operating range of ~27,780 km.

The *Revelle* would also serve as the platform from which vessel-based marine mammal observers would watch for marine mammals and sea turtles before and during airgun operations. The characteristics of the *Revelle* that make it suitable for visual monitoring are described in § II(3)(a).

Other details of the *Revelle* include the following:

Owner:	U.S. Navy
Operator:	Scripps Institution of Oceanography of the University of California
Flag:	United States of America
Date Built:	1996
Gross Tonnage:	3180
Compressors for Air Guns:	Price Air Compressors, 300 cfm at 1750 psi
Accommodation Capacity:	22 crew plus 37 scientists

(e) Airgun Description

The *Revelle* would tow a pair of 45-in^3 GI airguns and a 600-m streamer containing hydrophones along predetermined lines. Seismic pulses would be emitted at intervals of ~5–10 s (12.5–25 m).

The generator chamber of each GI gun, the one responsible for introducing the sound pulse into the ocean, is 45 in^3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape, and does not introduce more sound into the water. The two 45-in^3 GI guns would be towed 21 m behind the *Revelle*, 8 m apart side by side, at a depth of 2 m.

GI Airgun Specifications

Energy Source	Two GI guns of 45 in^3
Source output (downward)	0-peak is 3.4 bar-m (230.6 dB re 1 μPa·m); peak-peak is 6.2 bar-m (235.8 dB re 1 μPa·m)
Towing depth of energy source	2 m
Air discharge volume	Approx. 90 in^3
Dominant frequency components	0–188 Hz
Gun positions used	Two side-by-side guns 8 m apart
Gun volumes at each position (in^3)	45, 45

As the airguns are towed along the survey lines, the towed hydrophone array in the 600-m streamer would receive the reflected signals and transfer the data to the on-board processing system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel with gear deployed would be much higher than the limit of 5º per minute for a seismic vessel towing a streamer of more typical length (>>l km), ~20º. Thus, the maneuverability of the vessel would not be limited much during operations.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source. In this case, that would be ~230.6 dB re 1 μPa·m peak or 235.8 dB re 1 μPa·m peak-to-peak. Actual levels experienced by any organism more than 1 m from either GI airgun would be significantly lower.

A further consideration is that the rms[1] (root mean square) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (p or 0–p) or peak to peak (p–p) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received sound pressure level (SPL) of 160 dB re 1 μPa_{rms} in the far field would typically correspond to ~170 dB re 1 μPa_{p} or 176–178 dB re 1 $\mu Pa_{p\text{-}p}$, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak-to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

(f) Heat-flow Probe Description and Deployment

The heat-flow probe to be used on the *Revelle* consists of a lance 6 cm in diameter and 3.5 m long, a sensor tube housing thermistors and heater wires, and a 560-kg weight stand. The probe is lowered to the bottom, and a 12-kHz pinger attached to the wire ~50 m above the instrument monitors the distance between the probe and bottom. The probe is driven into the sediment by gravity, and temperatures within the sediment are measured with equally-spaced thermistors. On completion of a measurement, the instrument is hoisted 100–500 m above the sediment, the ship is maneuvered to a new position, and the process is repeated. Heat-flow measurements can generally be made at a rate of 1–2 h per measurement, ~15 min for the actual measurement and 45–90 min to reposition the ship and probe.

(g) Piston Core and Gravity Core Description and Deployment

The piston corer to be used on the R/V *Revelle* consists of (1) a piston core with a 10-cm diameter steel barrel up to ~18 m long with a 2300-kg weight and (2) a trigger core with a 10-cm diameter PVC plastic barrel 3 m long with a 230-kg weight, which are lowered concurrently into the ocean floor with 1.4-cm diameter steel cables.

The gravity corer consists of a 6-m long core pipe that takes a core sample ~10 cm in diameter, a head weight ~45 cm in diameter, and a stabilizing fin. It is lowered to the ocean floor with 1.4-cm diameter steel cable at 100 m/min speed.

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[1] The rms (root mean square) pressure is an average over the pulse duration.

(h) Multibeam Echosounder and Sub-bottom Profilers

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the entire cruise. The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS.

(3) Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.4.1 of the PEIS and will occur in two phases: pre-cruise planning and during operations. The following sections describe the efforts during both stages for the proposed action.

(a) Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activities begins during the planning phase of the proposed activities. Several factors were considered during the planning phase of the proposed activities, including

1. *Energy Source*—Part of the considerations for the proposed survey was to evaluate what source level was necessary to meet the research objectives. It was decided that the scientific objectives could be met using a low-energy source consisting of two 45-in^3 GI guns (total volume of 90 in^3) at a tow depth of ~2 m. The SIO portable multichannel seismic system's energy source level is one of the smallest source levels used by the science community for conducting seismic research.
2. *Survey Timing*—The PIs worked with SIO and NSF to identify potential times to carry out the survey, taking into consideration key factors such as environmental conditions (e.g., the seasonal presence of marine mammals), weather conditions, equipment, and optimal timing for other proposed research cruises. Some marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species.
3. *Mitigation Zones*—Received sound levels have been modeled by Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for a number of airgun configurations, including two 45-in^3 Nucleus G Guns, in relation to distance and direction from the airguns (Fig. 2). The model does not allow for bottom interactions, and is most directly applicable to deep water.

   Empirical data on the 190-, 180-, and 160-dB distances have been acquired for various airgun arrays based on measurements during acoustic verification studies conducted by L-DEO in the northern Gulf of Mexico in 2003 (6-, 10-, 12-, and 20-airgun arrays, and 2 GI airguns; Tolstoy et al. 2004) and 2007–2008 (18- and 36-airgun arrays; Tolstoy et al. 2009; Diebold et al. 2010). The empirical data for the 6-, 10-, 12-, and 20-airgun arrays indicate that, for deep water (>1000 m), the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy et al. 2004). Measurements were not made for the 2 GI airguns in deep water, but we propose to use the 160-dB radius predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative given the empirical results for the other arrays.

   The data also showed that the radius around the airguns where the received level would be 180 dB re 1 μPa_{rms}, the safety criterion applicable to cetaceans (NMFS 2000), varies with water depth. Correction factors were developed for water depths 100–1000 m and <100 m. The proposed surveys would occur in depths 200–3000 m, so only the correction factor for

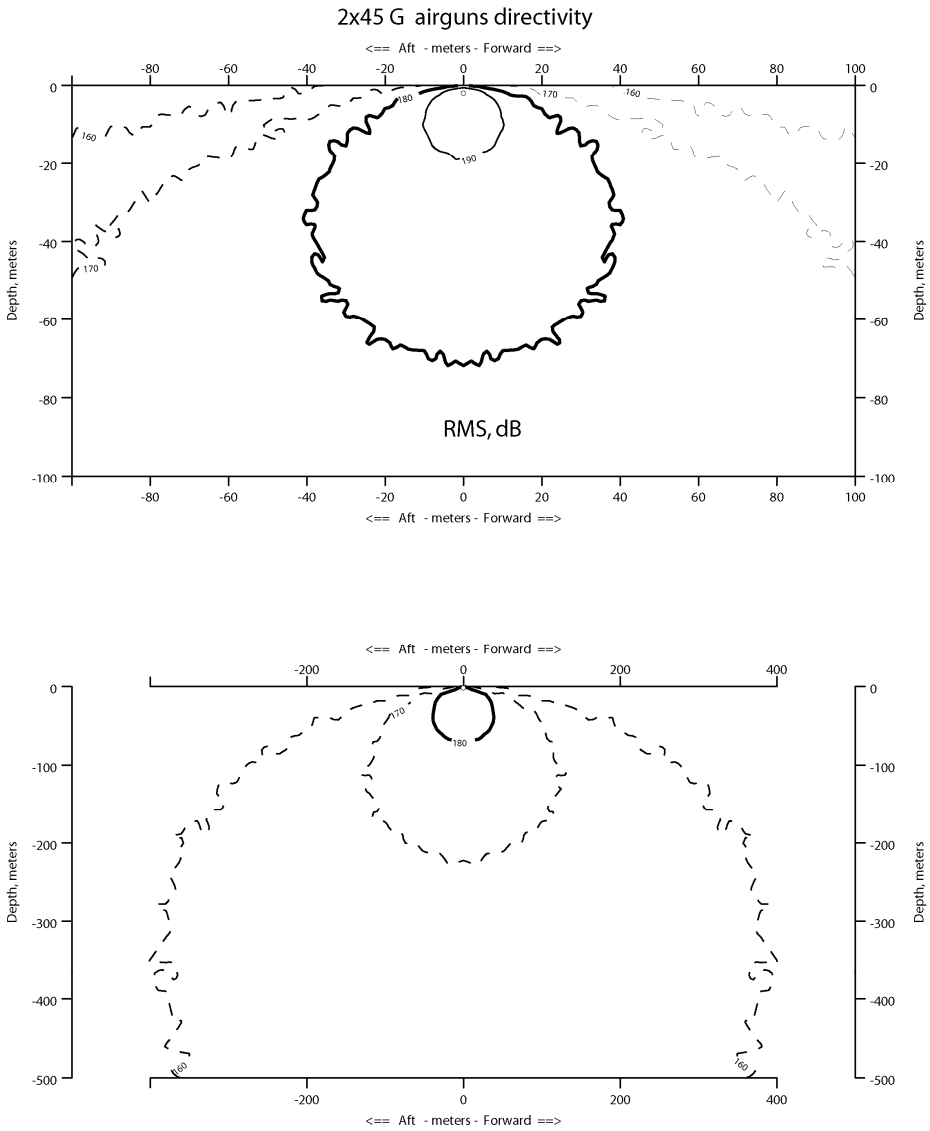

FIGURE 2. Modeled received sound levels from two 45-in^3 G Guns, similar to the two 45-in^3 GI airguns that would be used during the SIO surveys off New Zealand during May–June 2015. Model results were provided by L-DEO.

intermediate water depths is relevant here. The only empirical measurements made for intermediate depths (100–1000 m) were for the 36-aigun array in 2007–2008 (Diebold et al. 2010). The intermediate-water radii are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels very near offsets fall below the corrected mitigation curve (Fig. 16 in Diebold et al. [2010]).

The PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 45-in^3 GI airguns. A fixed full mitigation zone, or 160-dB "Safety Zone" was not defined in

the PEIS for the same suite of low-energy sources; therefore, L-DEO model results for 45-in^3 G Guns are used here to determine the 160-dB radius for the pair of 45-in^3 GI airguns.

Table 1 shows the 190- and 180-dB EZs for the pair of 45-in^3 GI guns based on the PEIS and the L-DEO modeled measurements for the 160-dB safety zone, the distances at which the rms sound levels are expected to be received in >1000-m and 100–1000 m water. Because the model results are for G Guns, which have more energy than GI airguns of the same size, the distances are overestimated. The 190- and 180-dB re 1 μPa_{rms} distances are the safety criteria as specified by NMFS (2000) for pinnipeds and cetaceans, respectively. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects. If marine mammals or sea turtles are detected in or about to enter the appropriate EZ, the airguns would be shut down immediately.

TABLE 1. Predicted distances to which 190 and 160 dB re 1 μPa_{rms} sound levels could be received from two 45-in^3 G guns, similar to the two 45-in^3 GI guns that would be used during the seismic surveys off New Zealand during May–June 2015 (model results provided by L-DEO). Distances to which 180 dB re 1 μPa_{rms} sound levels could be received are based on the standard EZ established in the PEIS.

Water depth	Predicted or established distances at received levels		
	190 dB	180 dB	160 dB
>1000 m	10	100 m	400 m
100–1000 m	15	100 m	600 m

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In December 2013, NOAA published draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2013), although at the time of preparation of this Draft EA, the date of release of the final guidelines and how they will be implemented are unknown. As such, this EA has been prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), and Wright (2014).

Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below.

(b) Operational Phase

SIO's operational mitigation measures are described in § 2.4.1.1 of the PEIS and include

- monitoring by protected species visual observers (PSVOs) for marine species;
- PSVO data and documentation; and
- mitigation during operations (speed or course alteration; shut-down and ramp-up procedures).

The proposed operational mitigation measures are standard for all low energy seismic cruises, per the PEIS, and therefore are not discussed further here. Special mitigation measures were considered for this cruise. It is unlikely that concentrations of large whales would be encountered, but if so, they would be avoided.

Marine mammals and sea turtles are known to occur in the proposed survey area. However, the number of individual animals expected to be approached closely during the proposed activities would be

relatively small in relation to regional population sizes. With the proposed monitoring and mitigation provisions, potential effects on most if not all individuals are expected to be limited to minor behavioral disturbance. Those potential effects are expected to have negligible impacts both on individual marine mammals and on the associated species and stocks.

To minimize the likelihood that potential impacts could occur to the species and stocks, airgun operations would be conducted in accordance with all applicable U.S. federal regulations and IHA requirements, and any required by New Zealand.

Alternative 1: Alternative Survey Timing

An alternative to issuing the IHA for the period requested and to conducting the project then would be to conduct the project at an alternative time, implementing the same monitoring and mitigation measures as under the Proposed Action, and requesting an IHA to be issued for that alternative time. The proposed time for the cruise in May–June 2015 is the most suitable time logistically for the *Revelle* and the participating scientists. If the IHA is issued for another period, it could result in significant delay and disruption not only of this cruise, but also of additional studies that are planned on the *Revelle* for 2015 and beyond. An evaluation of the effects of this Alternative Action is given in § IV.

Alternative 2: No Action Alternative

An alternative to conducting the proposed activities is the "No Action" alternative, i.e., do not issue an IHA and do not conduct the research operations. If the research was not conducted, the "No Action" alternative would result in no disturbance to marine mammals from the proposed activities.

The purpose of the proposed action is to conduct the proposed surveys and use the resulting sediment structure, seismic velocities, heat flow, and thermal conductivities to develop a process-based understanding of the thermal structure of the Hikurangi subduction zone, and expand this understanding by using regional observations of gas hydrate-related bottom-simulating reflections. Heat-flow measurements would be made in well-characterized sites, increasing the number of publicly-available heat-flow measurements from this continental margin by two orders of magnitude.

The "No Action" alternative could also, in some circumstances, result in significant delay of other studies that would be planned on the *Revelle* for 2015 and beyond, depending on the timing of the decision. Not conducting this cruise (no action) would result in less data and support for the academic institutions involved. Data collection would be an essential first step for a much greater effort to analyze and report information for the significant topics indicated. The field effort provides material for years of analyses involving multiple professors, students, and technicians. The lost opportunity to collect valuable scientific information would be compounded by lost opportunities for support of research infrastructure, training, and professional career growth. Effects of this Alternative Action are evaluated in § IV.

Alternatives Considered but Eliminated from Further Analysis

(1) Alternative E1: Alternative Location

The northern and middle study areas have been specifically selected as key locations to study along-strike variations in the deformation style of the Hikurangi margin. These sites are strategically located to address questions related to the depth of slow creep and seismogenesis. The combination of data from these areas would be used to characterize the thermal and hydrologic regime of the incoming plate, the deformation front and BSRs; and to develop new thermal models to better understand the

thermal and hydrologic regime of the Hikurangi subduction zone. The northern study area is co-located with an International Ocean Discovery Program (IODP) drilling proposal and a seafloor geodetic study. Work in the middle survey area off North Island takes advantage of an existing onshore/offshore seismic survey. The southern survey area specifically targets a region of large gas accumulation with intrusion of free gas and/or the presence of a significant amount of gas hydrate into the hydrate stability zone (high attenuation, or blanking, above the BSR). This region holds keys to understanding the hydrogeology and methane migration dynamics along this margin. Furthermore, the proposed research underwent the NSF merit review process, and the science, including the survey site locations, was determined to be meritorious.

(2) Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct marine geophysical research. At the present time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2014).

Table 2 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis.

III. AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) has focused mainly on those related to marine biological resources, as the proposed short-term activities have the potential to impact marine biological resources within the Project area. These resources are identified in Section III, and the potential impacts to these resources are discussed in Section IV. Initial review and analysis of the proposed Project activities determined that the following resource areas did not require further analysis in this Draft EA:

- *Transportation*—Only one vessel, the *Revelle*, would be used during the marine seismic survey, heat-flow measurements, and sediment coring. Therefore, projected increases in vessel traffic attributable to implementation of the proposed activities would constitute only a negligible portion of the total existing vessel traffic in the analysis area;
- *Air Quality/Greenhouse Gases*—Project vessel emissions would result from the proposed activities; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the survey area;
- *Land Use*—All activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities within the Project area would result from the proposed Project;
- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during proposed activities. All Project-related wastes would be disposed of in accordance with Federal and international requirements;

TABLE 2. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated.

Proposed Action	Description/Analysis
Proposed Action: Conduct marine geophysical surveys and associated activities in the southwestern Pacific Ocean	Under this action, the use of a low-energy seismic source, heat-flow measurements, and sediment coring are proposed. When considering mobilization, demobilization, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed activities would be expected to be completed in ~31 days. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in Sections III, IV, and V, respectively. The standard monitoring and mitigation measures identified in the PEIS would apply, along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternatives	**Description/Analysis**
Alternative 1: Alternative Survey Timing	Under this Alternative, SIO would conduct survey operations at a different time of the year to reduce impacts on marine resources and users, and improve monitoring capabilities. However, most marine mammal species are likely year-round residents in the survey area, so altering the timing of the proposed project likely would result in no net benefits for those species. Further, consideration would be needed for constraints for vessel operations and availability of equipment (including the vessel) and personnel. Limitations on scheduling the vessels include the additional research studies planned on the vessels for 2015 and beyond. The standard monitoring and mitigation measures identified in the PEIS would apply. These measures are described in further detail in this document (Section II [3]) and would apply to survey activities conducted during an alternative survey time period, along with any additional requirements identified by regulating agencies as a result of the change. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternative 2: No Action	Under this Alternative, no proposed activities would be conducted and seismic data would not be collected. Whereas this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the proposed action. Geological data of scientific value and relevance increasing our understanding of Earth processes and the thermal structure of the Hikurangi subduction zone would not be collected. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community and applicability of these data to other similar settings would not be achieved. No permits and authorizations, including an IHA, would be requested from regulatory bodies as the proposed action would not be conducted.
Alternatives Eliminated from Further Analysis	**Description**
Alternative E1: Alternative Location	The northern and middle study areas off North Island have been specifically selected as key locations to study along-strike variations in the deformation style of the Hikurangi margin. These areas are strategically located to address questions related to the depth of slow creep and seismogenesis. The southern survey area off South Island specifically targets a region of large gas accumulation with intrusion of free gas and/or the presence of a significant amount of gas hydrate into the hydrate stability zone (high attenuation, or blanking, above the bottom-simulating reflectors). This region holds keys to understanding the hydrogeology and methane migration dynamics along this margin. To our knowledge, no other sites meet all the requirements for our research objectives. Furthermore, the proposed research underwent the NSF merit review process, and the science, including the survey site locations, was determined to be meritorious.
Alternative E2: Alternative Survey Techniques	Under this alternative, SIO would use alternative survey techniques, e.g., marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At the present time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.

- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would result in only displacement and removal of a small amount of seafloor sediments through the collection of sediment cores. Proposed activities would not adversely affect geologic resources as only minor impacts would occur;
- *Water Resources*—No discharges to the marine environment are proposed within the Project area that would adversely affect marine water quality. Therefore, there would be no impacts to water resources resulting from the proposed Project activities;
- *Terrestrial Biological Resources*—All proposed Project activities would occur in the marine environment and would not impact terrestrial biological resources;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed Project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. The proposed activities would occur in water depths >200 m, outside the range for recreational SCUBA diving. The proposed activities are not located in areas where tourism/whale-watching activities take place. Human activities in the area around the survey vessel would be limited to fishing activities and other vessel traffic; however, no significant impacts on fishing would be anticipated particularly because of the short duration of the proposed activities (~1 month). Fishing and potential impacts to fishing are described in further detail in Sections III and IV, respectively. No other socioeconomic impacts would be anticipated as result of the proposed activities;
- *Visual Resources*—No visual resources would be anticipated to be negatively impacted as the area of operation is significantly outside of the land and coastal view shed; and
- *Cultural Resources*—There are no known cultural resources in the proposed Project area. Therefore, no impacts to cultural resources would be anticipated.

Oceanography

The study area is located in one province of one biome of Longhurst's (2007) pelagic biogeography: the South Subtropical Convergence Province (SSTC) of the Antarctic Westerly Winds Biome. The SSTC, lying between 35°S and 45°S, is characterized by a sharp decrease in the westerly winds of the Southern Ocean and strong downwelling. Through one or more of several different mechanisms, biomass of chlorophyll is enhanced in this province. The SSTC must contain a relatively high biomass of small fish and squid, because it supports concentrations of large pelagic fish such as mackerel (*Trachurus picturatus murphyi*) and southern bluefin tuna (*Thunnus maccoyi*), which leaves the SSTC only to enter warmer water to breed.

Marine Protected Areas

Marine Protected Areas (MPAs) are established as a tool for the preservation of biodiversity, often by restricting or banning certain fishing methods (Gormley et al. 2012). Recent analysis from a long-term study by Gormley et al. (2012) of Hector's dolphins in the Banks Peninsula MPA (south of the southern survey area) indicated that the survival and mean annual population growth of this species increased since the establishment of this protected area, representing the first empirical evidence that area-based protection measures can be effective for marine mammals. There are several other MPAs in the New

Zealand EEZ identified by Wood (2007), New Zealand Department of Conservation (NZDOC 2014a), New Zealand Government (2014a,b) and IUCN and UNEP (2014); see Figure 1.

The closest MPA to any of the proposed survey areas, the Kaikōura Marine Management Area (KMMA), is ~5 km south of the southern survey area off South Island. The proposed surveys and the associated Level B ensonified area would remain outside of the KMMA. The KMMA integrates several marine protection and fisheries mechanisms to manage coastal and marine resources, including marine reserves, whale and fur seal sanctuaries, and dedicated traditional and recreational fishing areas (NZDOC 2014a). The Te Rohe o Te Whānau Puha/Kaikōura Whale Sanctuary (Outer Zone), a component of the KMMA, is also just south of the southern survey area off South Island. Seismic activity is restricted within the Whale Sanctuary to protect whales and other marine mammals and their habitat from potential impacts of seismic survey activities (e.g., changes in behavior, such as moving away from the area), in order to provide greater certainty of whale locations for tourism operators (NZDOC 2014a). Otherwise, the closest MPAs are ≥30 km from the southern survey area and on the west coast of North Island, >130 km from the middle survey area (Fig. 1).

Marine Mammals

New Zealand is considered a hotspot for marine mammal species richness (Kaschner et al. 2011). Thirty-two marine mammal species, including 21 odontocetes, nine mysticetes, and two pinnipeds could occur in the proposed seismic survey areas (Table 3). Six of the 32 species are listed under the U.S. Endangered Species Act (ESA) as ***endangered***: the sperm whale, humpback whale, blue whale, fin whale, sei whale, and southern right whale.

Based on the New Zealand Threat Classification System, three of the species are *nationally critical*, including Bryde's whale, killer whale, and southern elephant seal (Baker et al. 2010). Two other species are ranked as *nationally critical* (Baker et al. 2010) but are not included in Table 3: Maui's dolphin (*Cephalorhynchu hectori maui*) is only found along the west coast of the North Island, and the northern range of the New Zealand sea lion (*Phocarctos hookeri*) is not expected to extend to the proposed survey area based on New Zealand's National Aquatic Biodiversity Information System (NABIS 2014). Three species ranked as *nationally endangered* could occur in the proposed study area: the southern right whale, Hector's dolphin, and the bottlenose dolphin (Baker et al. 2010).

An additional 18 species are categorized as *vagrant* under the New Zealand Threat Classification System (Baker et al. 2010) and were not included in Table 3; these include Arnoux's beaked whale (*Berardius arnouxi*), Ginkgo-toothed whale (*Mesoplodon ginkgodens*), pygmy beaked whale (*M. peruvianus*), dwarf sperm whale (*Kogia sima*), spectacled porpoise (*Phocoena dioptrica*), Type B, C, D killer whale (*Orcinus orca*), melon-headed whale (*Peponocephala electra*), Risso's dolphin (*Grampus griseus*), Fraser's dolphin (*Lagenodelphis hosei*), pantropical spotted dolphin (*Stenella attenuata*), striped dolphin (*S. coeruleoalba*), rough-toothed dolphin (*Steno bredanensis*), Antarctic fur seal (*Arctocephalus gazelle*), Subantarctic fur seal (*A. tropicalis*), leopard seal (*Hydrurga leptonyx*), Weddell seal (*Leptonychotes weddellii*), crabeater seal (*Lobodon carcinophagus*), and Ross seal (*Ommatophoca rossi*).

According to Jefferson et al. (2008), the distributional range of two more species may include New Zealand: Hubb's beaked whale (*Mesoplodon carlhubbsi*) and True's beaked whale (*M. mirus*). However, these two species are not discussed further, as there are no records of Hubb's beaked whale in New Zealand, and only a single record of True's beaked whale, which stranded on the west coast of South Island in November 2011 (Constantine et al. 2014). Neither of these species is categorized under the New Zealand Threat Classification System (Baker et al. 2010).

TABLE 3. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur near the proposed seismic survey area off New Zealand, in the southwest Pacific Ocean.

Species	Habitat	Occurrence in study area during May-June	Regional population size[1]	U.S. ESA[2]	IUCN[3]	NZ[4]
Mysticetes						
Southern right whale	Coastal, shelf	Common	12,000[5]	EN	LC	NE
Pygmy right whale	Coastal, oceanic	Rare	N.A.	NL	DD	DD
Humpback whale	Coastal, oceanic	Common	42,000[5]	EN	LC	M
Bryde's whale	Coastal, oceanic	Very rare	48,109[6]	NL	DD	NC
Dwarf minke whale	Coastal, shelf	Uncommon	750,000[7,8]	NL	LC	NT
Antarctic minke whale	Coastal, oceanic	Uncommon	750,000[7,8]	NL	DD	NT
Sei whale	Mostly offshore, pelagic	Uncommon	10,000[7]	EN	EN	M
Fin whale	Oceanic	Uncommon	15,000[7]	EN	EN	M
Blue whale	Coastal, shelf, offshore	Uncommon	2300 true[5]; 1500 pygmy[7]	EN	EN	M
Odontocetes						
Sperm whale	Slope, oceanic; canyons	Common	30,000[7]	EN	VU	NT
Pygmy sperm whale	Outer shelf, oceanic	Uncommon	N.A.	NL	DD	DD
Cuvier's beaked whale	Mostly over slope	Uncommon	600,000[7,9]	NL	LC	DD
Southern bottlenose whale	Oceanic	Rare	600,000[7,9]	NL	LC	DD
Shepherd's beaked whale	Oceanic	Rare	600,000[7,9]	NL	DD	DD
Hector's beaked whale	Oceanic	Rare	600,000[7,9]	NL	DD	DD
Gray's beaked whale	Oceanic	~Common	600,000[7,9]	NL	DD	DD
Andrew's beaked whale	Oceanic	Rare	600,000[7,9]	NL	DD	DD
Strap-toothed whale	Oceanic	Uncommon	600,000[7,9]	NL	DD	DD
Blainville's beaked whale	Slope	Very rare	600,000[7,9]	NL	DD	DD
Spade-toothed whale	Presumed oceanic	Very rare	600,000[7,9]	NL	DD	DD
Common bottlenose dolphin	Coastal, shelf, offshore	Common	N.A.	NL[10]	LC	NE
Short-beaked common dolphin	Oceanic	Abundant	N.A.	NL	LC	NT
Dusky dolphin	Shelf, slope	Common	12,000-20,000 NZ[11]	NL	DD	NT
Hourglass dolphin	Oceanic	Uncommon	150,000[7]	NL	LC	DD
Southern right whale dolphin	Oceanic	Uncommon	N.A.	NL	DD	NT
Hector's dolphin	Nearshore	Rare	7,400[12]	NL[13]	EN	NE
False killer whale	Oceanic, occ. shelf	Uncommon	N.A.	NL	DD	NT
Killer whale	Coastal, occ. offshore	Common	80,000[7]	NL	DD	N[14]
Long-finned pilot whale	Mostly pelagic	Common	200,000[7]	NL	DD	NT
Short-finned pilot whale	Oceanic	Uncommon	N.A.	NL	DD	M
Pinnipeds						
New Zealand fur seal		Common	50,000-100,000 NZ[12]	NL	LC	NT
Southern elephant seal		Rare	607,000[11]	NL	LC	NC

NZ = New Zealand; N.A. = Not Available; ETP = Eastern Tropical Pacific; occ. = occasionally

[1] Abundance for the Southern Hemisphere or Antarctic unless otherwise noted

[2] U.S. Endangered Species Act (ESA) (NMFS 2014); EN = Endangered; NL = Not Listed

[3] Codes for classifications from IUCN Red List of Threatened Species (IUCN 2014): EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient

[4] New Zealand Threat Classification System (Baker et al. 2010); NC = Nationally Critical; NE = Nationally Endangered; DD = Data Deficient; NT = Not Threatened; M = Migrant

[5] IWC (2014)

[6] IWC (1981)

[7] Boyd (2002)

[8] Dwarf and Antarctic minke whales combined
[9] All Antarctic beaked whales combined
[10] The Fiordland population in New Zealand is a candidate species for ESA listing
[11] NZDOC (2014b)
[12] Suisted and Neale (2004)
[13] Candidate species for ESA listing
[14] Only Type A is considered nationally critical.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. One of the qualitative analysis areas (QAAs) defined in the PEIS, the Sub-Antarctic, is located to the east of New Zealand and the proposed survey area, at 42ºS, 145ºW. The general distribution of mysticetes, odontocetes, and pinnipeds in the western South Pacific Ocean is discussed in § 3.6.3.8, § 3.7.3.8, and § 3.8.3.4 of the PEIS, respectively. The rest of this section deals specifically with species distribution in the proposed survey areas off the coast of New Zealand.

Few systematic surveys have been conducted in the waters of New Zealand, and these mainly consist of single-species surveys in shallow coastal waters (e.g., Dawson et al. 2004; Slooten et al. 2004, 2006); large-scale, multi-species surveys are lacking. Below we use various sources to describe the occurrence of marine mammals in the waters of New Zealand, such as opportunistic sighting records presented in previous reports, including the New Zealand Department of Conservation marine mammal sightings database.

(1) Mysticetes

Southern Right Whale (*Eubalaena australis*)

The southern right whale occurs throughout the Southern Hemisphere between ~20°S and 60°S (Kenney 2009). Right whales used to be widely distributed throughout New Zealand waters (Stewart and Todd 2001), but they were decimated by commercial whaling operations (Carroll et al. 2014). Their populations have been slow to recover (Patenaude and Baker 2001). However, numbers of right whales using the waters near the sub-Antarctic Auckland Islands have been increasing, and these islands appear to be primary wintering/calving areas for this species in New Zealand (Patenaude and Baker 2001), particularly Port Ross (Carroll et al. 2011a). Southern right whales are also known to winter at sub-Antarctic Campbell Island (Stewart and Todd 2001), as well as mainland New Zealand (Patenaude 2003). Movement of whales between the islands, as well as between the islands and the mainland (e.g., Patenaude et al. 2001; Childerhouse et al. 2010; Carroll et al. 2011b), suggests that right whales in New Zealand comprise a single stock (Carroll et al. 2011b). The population size in New Zealand was estimated at 2,169 individuals (Carroll et al. 2013).

Southern right whales calve in nearshore coastal waters during the winter and typically migrate to offshore feeding grounds during summer (Patenaude 2003). The Chatham Rise area is thought to be an important feeding area for right whales (Torres et al. 2013a). Based on a re-analysis of historical and other documents, Richards (2002) suggested that right whales arrived at South Island from sub-Antarctic waters during May and occurred in nearshore waters along the coast of New Zealand to calve. By October, whales had moved northward into offshore waters east of the Kermadec Islands, between 173 and 165°W, and 30 and 37°S, or over the northern half of the Louisville Ridge. During November, there was a marked shift southward and eastward, reaching 50°S around January. Clement (2010) noted that southern right whales likely use East Cape to navigate along the east coast of New Zealand during the northern and southern migrations.

Patenaude (2003) reported 110 sightings and 23 photo-identifications that were made between 1976 and 2002 around New Zealand. All of these records were for nearshore waters (generally within 200 m) along the three main islands of New Zealand. Patenaude (2003) noted that the majority of sightings were made during the winter (59%) and spring (23%), with fewer sightings during summer (7%) and fall (6%). Thirty percent of all sightings were made along the east coast of North Island, some of which occurred near the proposed northern survey area. The majority of sightings along the east coast of North Island were made within coastal waters of the East Coast/Hawke's Bay conservancy (Patenaude 2003). The area from Hawke's Bay to Bay of Plenty appears to be a primary calving area for right whales during August–November (Patenaude 2003). At least another 30 sightings have been reported for the region between Bay of Plenty and Hawke's Bay since 2008, mainly along the East Cape headland (Clement 2010). A right whale record for spring also exists for deep waters just to the south of the proposed southern survey area (Torres et al. 2013b). Patenaude (2003) reported a total of seven fall sightings off New Zealand; one sighting was made off North Island (Hauraki Gulf), there were two sighting records for eastern Cook Strait, one off Stewart Island, and three off South Island—one on the southwest and two on the southeast coast. Berkenbusch et al. (2013) reported 42 sightings during May–June 1970–2013.

During 2005, two right whales were reported on the west coast of New Zealand, two sightings were made at 35°15'S near Bay of Islands, and one sighting occurred north off Cape Reinga at 33°25'S (Richards 2009). In 2006, 64 sightings were reported off the North and South Islands, including one near Whangarei at 35°37'S (Richards 2009). During 2007, more than 60 sightings were made off the main islands of New Zealand, and in 2008, 43 sightings of at least 64 whales were made. In 2009, up to 1 August, more than 50 sightings had been made off North and South Islands (Richards 2009). In addition, there have been at least two strandings of southern right whales in New Zealand (Berkenbusch et al. 2013).

Habitat use modeling for New Zealand by Torres et al. (2013c) showed that the proposed survey areas have low habitat suitability for the southern right whale; sheltered coastal areas had the highest habitat suitability, at least during winter. Torres et al. (2013a,d) reported that southern right whale presence increases in water temperatures 7–13°C, with closer proximity to the subtropical front, and a mixed layer depth of <100 m.

The available information suggests that it is possible that southern right whales could be migrating through the proposed survey area at the time the survey is scheduled (May–June). However, the low population numbers indicate that few, if any, would be encountered. Thus, southern right whale sightings are likely to be uncommon in the project area during the austral fall.

Pygmy right whale (*Caperea marginata*)

The pygmy right whale's distribution is circumpolar in the Southern Hemisphere between 30°S and 55°S in oceanic and coastal environments (Jefferson et al. 2008; Kemper 2009). Pygmy right whales appear to be non-migratory, although there may be some movement inshore in spring and summer (Kemper 2002; Jefferson et al. 2008). Sightings of pygmy right whales in the southwestern Pacific Ocean are rare (Jefferson et al. 2008). Matsuoka et al. (2005) reported a sighting of 14 pygmy right whales at 46°26'S, 177°18'E in January 2001 that had been feeding in the area; this suggests that the Subtropical Convergence may be an important feeding area for this species during the austral summer (Matsuoka et al. 2005). In addition, Kemper et al. (2013) reported a sighting in very shallow water of Cook Strait during October 2002, and Berkenbusch et al. (2013) noted a sighting off the east coast of Northland. Other records include one whale that was captured at Stewart Island in 1874, and a skull that was trawled up by a fishing vessel at Chatham Rise (Kemper et al. 2013).

There have been at least 56 strandings in New Zealand, including at least eight live strandings (Kemper et al. 2013). Berkenbusch et al. (2013) reported a total of 11 live strandings. Most strandings were concentrated at Stewart Island, Cook Strait, and the Auckland area; one stranding was also reported for Hawke's Bay (Kemper 2002). Strandings appear to be associated with favorable feeding areas in New Zealand, including upwelling regions, along the Subtropical Convergence, and the Southland Current (Kemper 2002; Kemper et al. 2013). Kemper et al. (2013) reported live strandings for the west coast of North Island (n = 4), Cook Strait (2), east coast of South Island (1), and Stewart Island (1). Records have been made throughout the year, but appear to be more frequent during austral spring and summer (Kemper et al. 2013).

Although Kemper (2009) noted that the number of strandings indicate that the pygmy right whale may be relatively common in Australia and New Zealand, it seems unlikely that this species would be encountered in the survey areas because of the scarcity of sightings.

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all of the World's oceans (Jefferson et al. 2008). Although considered to be mainly a coastal species, humpback whales often traverse oceanic areas while migrating (Jefferson et al. 2008). Humpbacks migrate from winter breeding areas in the tropics to temperate or polar feeding areas in the summer (Jefferson et al. 2008). In the South Pacific Ocean, there are several distinct winter breeding grounds, including eastern Australia and Oceania (Anderson et al. 2010; Garrigue et al. 2011). Whales from Oceania migrate past New Zealand to Antarctic summer feeding areas (Constantine et al. 2007; Garrigue et al. 2000, 2010). The northern migration along the New Zealand coast occurs between May and August, with a peak in late June to mid July; the southern migration occurs from September to December, with a peak in late October to late November (Dawbin 1956). Dawbin (1956) suggested that northern migrating humpback whales travel along the east coast of South Island and then move along the east coast of North Island or through Cook Strait and up the west coast of North Island; smaller numbers migrate around southwestern South Island. Most southern migrating whales travel along the west coast of New Zealand, whereas some migrate along the east coast of North Island south to East Cape before moving to offshore waters (Dawbin 1956). Clement (2010) also noted that humpback whales likely use East Cape to navigate along the east coast of New Zealand during the northern and southern migrations. Humpback whales that migrate past New Zealand are likely part of the International Whaling Commission (IWC) Area V Antarctic management zone (Dawbin 1956; Constantine et al. 2007), and also part of IWC breeding stock E (Constantine et al. 2007).

Large numbers of humpback whales were taken around New Zealand during the commercial whaling era, and the recovery of humpbacks in those waters has been slow (Gibbs and Childerhouse 2000; Constantine et al. 2007). Gibbs and Childerhouse (2000) reported a total of 157 sightings consisting of 437 live individuals for the east coast of New Zealand during 1970 to 1999; approximately half were from Kaikoura, on the east coast of South Island, and Cook Strait. Over half of the total sightings were made during May–August; most sightings were made off the eastern coast of South Island (Gibbs and Childerhouse 2000), although none were reported in the proposed southern survey area. Torres et al. (2013b) reported one summer humpback whale sighting in the proposed southern survey area near the 2000-m isobath, and several other humpback sightings just south of the southern survey area during spring, summer, and autumn. Gibbs and Childerhouse (2000) did not report any humpback records for the study areas off North Island, although numerous sightings were made in the Bay of Plenty to the northwest.

Since 1999, at least 30 additional sightings have been made between Hawke's Bay and Bay of Plenty (Clement 2010). Most sightings in the Bay of Plenty were made between August and January; sightings in the coastal waters of Gisborne District were made in June and July (Clement 2010). Several sightings of humpbacks have been reported for shelf waters adjacent to the northern survey area (Clement 2010). Clement (2010) noted that humpbacks regularly occur off eastern North Island during their migration, although they appear to be more prevalent in Hawke's Bay and coastal waters of the Gisborne District during fall migration. Clement (2010) also reported that humpbacks have been observed feeding in the Bay of Plenty before migrating south for the summer. In addition, there have been at least 20 humpback whale strandings in New Zealand (Berkenbusch et al. 2013).

A total of 34 whales were photo-identified off New Zealand during 1994–2004 (Constantine et al. 2007); most were sighted during a 2004 survey in Cook Strait (Gibbs and Childerhouse 2004 *in* Constantine et al. 2007). In addition, humpback whale vocalizations were detected off Great Barrier Island, northern New Zealand, from February through September 1997, with peak calling activity from May through September (McDonald 2006).

It is likely that some humpback whales will be encountered in the survey area during May–June as they migrate from summer feeding grounds in the Antarctic to winter breeding areas in the tropics.

Bryde's Whale (*Balaenoptera edeni/brydei*)

The distribution of Bryde's whale is circumglobal, but it generally occurs in tropical and sub-tropical areas (Jefferson et al. 2008). In New Zealand, Bryde's whale distribution is largely restricted to warmer waters north of East Cape off North Island (Baker 1999), within ~18 km from shore (NABIS 2014). The west and southeast coast of North Island, including the proposed survey areas, are not included in the species range description by NABIS (2014). Baker (1999) noted that Bryde's whales migrate along the northeast coast of North Island on a seasonal basis. Bryde's whales are found in the Bay of Plenty, Hauraki Gulf, and the eastern coast of Northland throughout the year (O'Callaghan and Baker 2002; Clement 2010; NZDOC 2009; Baker and Madon 2007; Wiseman 2008; Baker et al. 2010; Wiseman et al. 2011; Berkenbusch et al. 2013). Bryde's whale vocalizations were also detected year-round off Great Barrier Island, northern New Zealand, during 1997 (McDonald 2006). Berkenbusch et al. (2013) noted that there were 33 strandings for New Zealand during 1970–2013, and Baker et al. (2010) reported 38 mortalities from 1989 to 2008, including vessel strikes.

Although there have been strandings along the coast adjacent to the northern survey area (Clement 2010), a sighting in offshore waters southeast of New Zealand (Berkenbusch et al. 2013), and three sightings within the South Taranaki Bight region (Torres 2012), Bryde's whale is unlikely to occur in the proposed survey areas.

Dwarf minke (*Balaenoptera acutorostrata*) and Antarctic minke whale (*B. bonaerensi*)

The common minke whale has a cosmopolitan distribution ranging from the tropics and sub-tropics to the ice edge in both hemispheres (Jefferson et al. 2008). Its distribution in the South Pacific is not well known (Jefferson et al. 2008). A smaller form (unnamed subspecies) of the common minke whale, known as the dwarf minke whale, occurs in the Southern Hemisphere where its distribution overlaps with that of the Antarctic minke whale during summer (Perrin and Brownell 2009). The range of the dwarf minke whale is thought to extend as far south as 65°S (Jefferson et al. 2008) and as far north as 11°S off Australia, where it can be found year-round (Perrin and Brownell 2009). The Antarctic minke whale has a circumpolar distribution in coastal and offshore areas of the Southern Hemisphere from ~7°S to the ice

edge (Jefferson et al. 2008). Antarctic minke whales are found between 60°S and the ice edge during the austral summer; in the austral winter, they are mainly found at breeding grounds at mid latitudes, including 10°S–30°S and 170°E–100°W in the Pacific, off eastern Australia, western South Africa, and northeastern Brazil (Perrin and Brownell 2009).

Populations of minke whales around New Zealand are migratory (Baker 1983). Clement (2010) noted that minke whales likely use East Cape to navigate along the east coast of New Zealand during the northern and southern migrations. Small groups of minke whales have been sighted off New Zealand (Baker 1999; Clement 2010; Berkenbusch et al. 2013; Torres et al. 2013b). Clement (2010) noted that at least one to two common minke whales are seen annually in the Bay of Plenty from mid winter through early summer; however, according to Berkenbusch et al. (2013), minke whales have also occurred there during austral fall (May–June). Minke whale sightings have also been made during fall in Hawke's Bay and in eastern Cook Strait during summer (Berkenbusch et al. 2013). Offshore sightings east of North Island and South Island, including at Chatham Rise southeast of the proposed survey areas, have primarily been made during spring and summer, although sightings have also been reported for fall and winter (Berkenbusch et al. 2013; Torres et al. 2013b).

Between 1970 and 2013, there were 85 strandings of dwarf minke whales in New Zealand, including 34 live strandings (Berkenbusch et al. 2013). Strandings occurred along North and South Island, including Hawke's Bay, Cook Strait, and Bay of Plenty (Brabyn 1991). In addition, 17 Antarctic minke whales stranded in New Zealand between 1970 and 2013, including 10 live strandings (Berkenbusch et al. 2013).

Although minke whales are considered to be one of the most frequently sighted rorquals in the area, both species are likely to be uncommon in the proposed survey areas during May–June.

Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins (Horwood 2009). It undertakes seasonal migrations to feed in sub-polar latitudes during summer, returning to lower latitudes during winter to calve (Horwood 2009). In the South Pacific, sei whale typically concentrate between the sub-tropical and Antarctic convergences during the summer (Horwood 2009).

Numerous sightings of sei whales have been made in New Zealand waters (Baker 1999; Clement 2010; Berkenbusch et al. 2013; Torres et al. 2013b). Although most sightings have been made during October–April (Clement 2010), there are records of this species throughout the year, including May and June (Berkenbusch et al. 2013). The majority of sightings are for the east coast of North Island in shelf waters, including the Hauraki Gulf, Bay of Plenty, and East Cape (Clement 2010; Berkenbusch et al. 2013); nonetheless, sightings have also been recorded for the east coast of South Island, Cook Strait, Stewart Island, the west coast of New Zealand, and the Chatham Islands (Berkenbusch et al. 2013). Large groups (>100 whales) and single sei whales have been reported for Bay of Plenty and the Hawke's Bay area (Clement 2010). Some of the sightings have occurred in and near the proposed survey areas off North and South Island (see Clement 2010; Berkenbusch et al. 2013). Fall sightings have been reported for East Cape and eastern Cook Strait, as well as other areas around New Zealand (Berkenbusch et al. 2013). In addition, at least eight strandings have been reported for New Zealand, including strandings in the Bay of Plenty and Cook Strait (Brabyn 1991)

The sei whale is likely to be uncommon in the proposed survey area, especially during May–June.

Fin Whale (*Balaenoptera physalus*)

The fin whale occurs in all major oceans; however, its overall range and distribution is not well known (Jefferson et al. 2008). Northern and southern fin whale populations are distinct and are sometimes recognized as different subspecies (Aguilar 2009). In the Southern Hemisphere, fin whales are usually distributed south of 50ºS in the austral summer, and they migrate northward to breed in the winter (Gambell 1985).

Numerous sightings of fin whales have been made in New Zealand waters, mostly during spring and summer, although records exist throughout the year (Baker 1999; Clement 2010; Berkenbusch et al. 2013). The majority of sightings are for the east coast of North Island in shelf waters, including the Hauraki Gulf, Bay of Plenty, and East Cape (Clement 2010; Berkenbusch et al. 2013), although sightings have also been recorded for the east coast of South Island, Cook Strait, and the west coast of New Zealand (Berkenbusch et al. 2013). Some of the sightings have occurred in and near the proposed survey areas off North and South Island (see Clement 2010; Berkenbusch et al. 2013). Fall sightings have been reported for East Cape and Banks Peninsula, as well as other areas around New Zealand (Berkenbusch et al. 2013). Distant fin whale vocalizations were detected off Great Barrier Island, northern New Zealand, during June–September 1997 (McDonald 2006). At least 13 fin whale strandings have been reported for New Zealand, including strandings in Hawke's Bay, Bay of Plenty, and Cook Strait (Brabyn 1991).

Fin whales could be encountered during the proposed survey, as they migrate to winter breeding areas at the time of the survey.

Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution, but tends to be mostly pelagic, only occurring nearshore to feed and possibly breed (Jefferson et al. 2008). Three subspecies of blue whale are recognized: *B. m. musculus* in the Northern Hemisphere; *B. m. intermedia* (the true blue whale) in the Antarctic, and *B. m. brevicauda* (the pygmy blue whale) in the sub-Antarctic zone of the southern Indian Ocean and the southwestern Pacific Ocean (Sears and Perrin 2009). The pygmy and Antarctic blue whale occur in New Zealand (Branch et al. 2007). The blue whale is considered rare in the Southern Ocean (Sears and Perrin 2009). Most pygmy blue whales do not migrate south during summer; however, Antarctic blue whales are typically found south of 55°S during summer, although some are known not to migrate (Branch et al. 2007).

Blue whales have been sighted throughout New Zealand waters year-round, with most sightings reported for the South Taranaki Bight and the east coast of Northland (Berkenbusch et al. 2013; Torres 2013). Most sightings off the east coast, including at East Cape and Bay of Plenty, occurred during spring and summer (Clement 2010; Berkenbusch et al. 2013). Fall sightings were made in Cook Strait, South Taranaki Bight, and offshore from Banks Peninsula (Berkenbusch et al. 2013; Olson et al. 2013; Torres 2013). Sightings have been made near the proposed northern and middle survey areas off North Island, as well as near the southern area off South Island during summer (Berkenbusch et al. 2013; Torres 2013; Torres et al. 2013b). One blue whale was sighted on the Chatham Rise south of the survey area during fall (Torres et al. 2013b).

Blue whale vocalizations specific to New Zealand waters were detected within 2 km from Great Barrier Island, northern New Zealand, from June to December 1997; Southern Ocean blue whale songs were detected further offshore during May–July (McDonald 2006). Blue whale vocalizations were also detected within the southern survey area off the northeastern South Island during March 2013 (Miller et al. 2013).

The South Taranaki Bight, between North and South Island, appears to be a foraging area for blue whales, as the upwelling in this area likely concentrates their euphausiid prey (Torres 2013). There are likely other feeding areas in New Zealand for blue whales (Olson et al. 2013). There have been 20 strandings of blue whales on the New Zealand coast (Torres 2013), including at least three strandings of pygmy blue whales (Berkenbusch et al. 2013). One blue whale stranding was reported for Hawke's Bay, several were reported in the South Taranaki Bight/Cook Strait area, and the remainder were spread out along the rest of the coastline (Torres 2013).

Based on the available information, it is possible that pygmy or true blue whales could be encountered in the proposed survey areas during May–June.

(2) Odontocetes

Sperm Whale (*Physeter macrocephalus*)

Sperm whales have an extensive worldwide distribution which is linked to social structure: mixed groups of adult females and juveniles of both sexes generally occur in tropical and subtropical waters, whereas adult males are commonly found alone or in same-sex aggregations, often occurring in higher latitudes outside the breeding season (Best 1979; Rice 1989). Females typically inhabit waters >1000 m deep and latitudes <40° (Rice 1989). Torres et al. (2013a) found that sperm whale distribution is associated with proximity to geomorphologic features, as well as surface temperature.

Sperm whales are widely distributed throughout New Zealand waters, occurring in offshore and nearshore regions, with decreasing abundance away from New Zealand toward the central South Pacific Ocean (Gaskin 1973). Year-round sightings of sperm whales have been made throughout New Zealand waters, both close to shore and offshore (Berkenbusch et al. 2013; Torres et al. 2013b). Clement (2010) noted that male and female sperm whales likely migrate through the Hawke's Bay area during summer and fall. An aggregation of sperm whales is known to occur off Kaikoura Peninsula, on the northeastern coast of South Island; this area is almost exclusively used by males on a year-round basis (Lettevall et al. 2002; Richter et al. 2003). Letteval et al. (2002) reported that 192 sperm whales used the area off Kaikoura Peninsula over the course of 1990–2001. Some individuals spend several weeks or months in the area at a time, revisiting the location over several seasons; some other individuals are only seen once, and are considered transients (Jaquet et al. 2000; Letteval et al. 2002). The mean residency times of sperm whales in the area was 42 days, and the mean number of whales in the area at any one time was 13.8 (Lettevall et al. 2002). More recently, Sagnol et al. (2014) reported a mean of four sperm whales were present in the area at any one time.

Childerhouse et al. (1995) noted that 60 to 108 whales may be present off Kaikoura in any season. Whales in that area are seen closer to shore in the winter than in summer, possible because of changes in the distribution of their prey (Jaquet et al. 2000; Richter et al. 2003). During summer, almost all sightings are made in waters deeper than 1000 m, whereas during winter, sperm whale distribution is more diffuse, with more whales seen south of Kaikoura, over the Conway Trench and in waters 500–1000 m deep (Jaquet et al. 2000; Richter et al. 2003).

Sperm whale sightings have been reported throughout the year in and near the proposed northern and middle survey areas, as well as the southern survey area (Clement 2010; Berkenbusch et al. 2013; Torres et al. 2013b). There have been at least 211 strandings reported for New Zealand (Berkenbusch et al. 2013), including along the coast of East Cape, and in Hawke's Bay and Cook Strait (Brabyn 1991).

Sperm whales, particularly adult males, are likely to be seen in the proposed survey areas during May–June.

Pygmy Sperm Whale (*Kogia breviceps*)

The pygmy sperm whale is distributed widely throughout tropical and temperate seas, but its precise distribution is unknown because much of what we know of the species comes from strandings (McAlpine 2009). Although there are few useful estimates of abundance for pygmy sperm whales anywhere in their range, they are thought to be common in some areas. They are known to occur in tropical and warm temperate areas of the western South Pacific Ocean.

There have been very few sightings of pygmy sperm whales in New Zealand. The lack of sightings is likely because of their subtle surface behavior and long dive times (Clement 2010). Berkenbusch et al. (2013) reported one sighting off Banks Peninsula and one in the Bay of Plenty, and Clement (2010) mapped a sighting off the north coast of East Cape. The pygmy sperm whale is one of the most regularly stranded cetacean species in New Zealand, suggesting that this species is not uncommon in those waters (Clement 2010). A total of 355 strandings were reported between 1970 and 2013; nearly half of those (154) were live strandings (Berkenbusch et al. 2013). The East Cape/Hawke's Bay area seems to be a key area for this species, as stranding events are common there (Suisted and Neale 2004; Clement 2010; Berkenbusch et al. 2013). Half of all female strandings at Hawke's Bay involved calves, suggesting that this area is an important breeding ground (Brabyn 1991; Clement 2010; Berkenbusch et al. 2013). Based on stranding data, the pygmy sperm whale calving season in New Zealand is during summer months (Baker 1999).

Pygmy sperm whales are likely to occur near the survey areas.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread of the beaked whales, although it is not found in polar waters (Heyning 1989). New Zealand has been reported as a hotspot for beaked whales (MacLeod and Mitchell 2006), with both sightings and strandings of Cuvier's beaked whales in the area (MacLeod et al. 2006). Beaked whale sightings in New Zealand primarily consist of *Mesoplodon* spp. and Cuvier's beaked whales (MacLeoad and Mitchell 2006), with sightings of Cuvier's beaked whale reported for the Bay of Plenty (Clement 2010). Cuvier's beaked whales also strand relatively frequently in New Zealand; at least 82 strandings have been reported (Berkenbusch et al. 2013). Strandings have been reported for East Cape, Mahia Peninsula, Hawke's Bay, Cook Strait, the southeast coast of North Island, and northeastern coast of South Island (Brabyn 1991; Clement 2010).

Cuvier's beaked whale could be encountered during the proposed surveys.

Southern Bottlenose Whale (*Hyperoodon planifrons*)

The southern bottlenose whale can be found throughout the Southern Hemisphere from 30°S to the ice edge, with most sightings occurring from ~57°S to 70°S (Jefferson et al. 2008). It is apparently migratory and is found in Antarctic waters during the summer (Jefferson et al. 2008). New Zealand has been reported as a hotspot for beaked whales (MacLeod and Mitchell 2006), with both sightings and strandings of southern bottlenose whales in the area (MacLeod et al. 2006). At least four sightings have been reported for waters around New Zealand, including one in Hauraki Gulf, one on the southwest coast of South Island, and two sightings south of New Zealand within the EEZ (Berkenbusch et al. 2013). In addition, 24 strandings were reported for New Zealand between 1970 and 2013 (Berkenbusch et al. 2013).

Strandings have been reported for East Cape, Hawke's Bay, southern North Island, northeastern South Island, and Cook Strait (Brabyn 1991; Clement 2010).

The southern bottlenose whale could be encountered during the proposed surveys.

Shepherd's Beaked Whale (*Tasmacetus shepherdi*)

Based on known records, it is likely that Shepherd's beaked whale has a circumpolar distribution in the cold temperate waters of the Southern Hemisphere (Mead 1989a). This species is primarily known from strandings, most of which have been recorded in New Zealand (Mead 2009). Thus, MacLeod and Mitchell (2006) suggested that New Zealand may be a globally important area for Shepherd's beaked whale. One possible sighting was made near Christchurch (Watkins 1976). At least 20 specimens have stranded on the coast of New Zealand (Baker 1999), including in southern Taranaki Bight and Banks Peninsula (Brabyn 1991).

Shepherd's beaked whale could be encountered during the proposed surveys.

Andrew's beaked whale (*Mesoplodon bowdoini*)

Andrew's beaked whale has a circumpolar distribution in temperate waters of the Southern Hemisphere (Baker 2001). This species is known only from stranding records between 32°S and 55°S, with more than half of the strandings occurring in New Zealand (Jefferson et al. 2008). Thus, New Zealand may be a globally important area for Andrew's beaked whale (MacLeod and Mitchell 2006). In particular, Clement (2010) suggested that the East Cape/Hawke's Bay waters may be an important habitat for Andrew's beaked whale.

There have been at least 19 strandings in New Zealand (Berkenbusch et al. 2013), at least 10 of which have been reported in the spring and summer (Baker 1999). Strandings have occurred from the North Island to the sub-Antarctic Islands (Baker 1999), including East Cape, Hawke's Bay, and Cook Strait (Brabyn 1991; Clement 2010).

Andrew's beaked whale could be encountered during the proposed surveys.

Blainville's beaked whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and temperate waters of all oceans (Jefferson et al. 2008). It has the widest distribution throughout the world of all *Mesoplodon* species (Mead 1989b). According to Berkenbusch et al. (2013), there have been at least three strandings of Blainville's beaked whale in New Zealand. One stranding has been reported for the west coast of Northland and another for Hawke's Bay (Baker and van Helden 1999).

Blainville's beaked whale could be encountered during the proposed surveys.

Gray's beaked whale (*Mesoplodon grayi*)

Gray's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2002). Gray's beaked whale primarily occurs in deep waters beyond the edge of the continental shelf (Jefferson et al. 2008). Some sightings have been made in very shallow water, usually of sick animals coming in to strand (Gales et al. 2002; Dalebout et al. 2004). One Gray's beaked whale was observed within 200 m of the shore off southwestern Australia off and on for periods of weeks before disappearing (Gales et al. 2002). There are many sighting records from Antarctic and sub-Antarctic waters, and in summer months they appear near the Antarctic Peninsula and along the shores of the continent (sometimes in the sea ice).

New Zealand has been reported as a hotspot for beaked whales (MacLeod and Mitchell 2006), with both sightings and strandings of Gray's beaked whales in the area (MacLeod et al. 2006). In particular, the area between the South Island of New Zealand and the Chatham Islands has been suggested to be a hotspot for sightings of this species (Dalebout et al. 2004). In addition, a mother and calf Grays' beaked whale was observed in Mahurangi Harbor on the North Island over five consecutive days in June 2001 (Dalebout et al. 2004). Gray's beaked whale is the most common beaked whale to strand in New Zealand with at least 252 records (Berkenbusch et al. 2013). Stranding records exist along the east coasts of North and South Islands, including Bay of Plenty, Mahia Peninsula, Hawke's Bay, and Cook Strait (Brabyn 1991; Clement 2010).

Gray's beaked whale could be encountered during the proposed surveys.

Hector's beaked whale (*Mesoplodon hectori*)

Hector's beaked whale is thought to have a circumpolar distribution in deep oceanic temperate waters of the Southern Hemisphere (Pitman 2002). Based on the number of stranding records for the species, it appears to be relatively rare. One individual was observed swimming close to shore off southwestern Australia for periods of weeks before disappearing (Gales et al. 2002). This was the first live sighting in which species identity was confirmed.

MacLeod and Mitchell (2006) suggested that New Zealand may be a globally important area for this species. There are sighting and stranding records of Hector's beaked whales for New Zealand (MacLeod et al. 2006; Clement 2010). One sighting has been reported for the Bay of Plenty on the North Island (Clement 2010). At least 12 strandings have been reported for New Zealand (Berkenbusch et al. 2013), including records for the Bay of Plenty, East Cape, Mahia Peninsula, Hawke's Bay, and Cook Strait (Brabyn 1991; Clement 2010).

Hector's beaked whale could be encountered during the proposed surveys.

Spade-toothed beaked whale (*Mesoplodon traversii*)

The spade-toothed beaked whale is the name proposed for the species formerly known as Bahamonde's beaked whale (*M. bahamondi*). Recent genetic evidence has shown that they belong to the species first identified by Gray in 1874 (van Helden et al. 2002). The species is considered relatively rare and is known from only four records, three of which are from New Zealand (Thompson et al. 2012). One mandible was found at the Chatham Islands in 1872; two skulls were found at White Island, Bay of Plenty, in the 1950s; a skull was collected at Robinson Crusoe Island, Chile, in 1986; and most recently, two live whales, a female and a male, stranded at Opape, in the Bay of Plenty, and subsequently died (Thompson et al. 2012). MacLeod and Mitchell (2006) suggested that New Zealand may be a globally important area for the spade-toothed beaked whale.

The spade-toothed beaked whale could be encountered during the proposed surveys.

Strap-toothed beaked whale (*Mesoplodon layardii*)

The strap-toothed beaked whale is thought to have a circumpolar distribution in temperate and sub-Antarctic waters of the Southern Hemisphere, mostly between 35° and 60°S (Jefferson et al. 2008). Based on the number of stranding records, it appears to be fairly common. Strap-toothed whales are thought to migrate northward from Antarctic and sub-Antarctic latitudes during April–September (Sekiguchi et al. 1996).

New Zealand has been reported as a hotspot for beaked whales (MacLeod and Mitchell 2006), with both sightings and strandings of strap-toothed beaked whales in the area (MacLeod et al. 2006; Clement 2010). Strap-toothed whales commonly strand in New Zealand, with at least 78 strandings reported (Berkenbusch et al. 2013). Most strandings occur between January and April, suggesting some seasonal austral summer inshore migration (Baker 1999). Strap-toothed whale strandings have been reported for the east coast of North Island and South Island, including the Bay of Plenty, East Cape, Hawke's Bay, and Cook Strait (Brabyn 1991; Clement 2010).

The strap-toothed beaked whale could be encountered during the proposed surveys.

Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2008). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). In New Zealand, the inshore form appears to be more common than the offshore ecotype, and is restricted to waters north of 47°S in water <500 m deep (NABIS 2014). The offshore form occurs more widely (Baker et al. 2010), and is seen off eastern Northland during the summer and autumn (NABIS 2014). Baker et al. (2010) noted that there are 900–1000 bottlenose dolphins in inshore waters.

Although the bottlenose dolphin can occur along the entire coast of New Zealand, there are three hotspots (NABIS 2014) or main areas of distribution in New Zealand, including Northland, Marlborough Sounds, and Fiordland (Tezanos-Pinto et al. 2009). These three areas are treated as containing distinct populations that are mostly isolated from one another (Tezanos-Pinto et al. 2009). Even though the three populations occur in coastal waters, they are more similar to other offshore ecotypes than coastal ecotypes (Tezanos-Pinto et al. 2009).

Sightings of bottlenose dolphins have been made in shelf and deeper waters (>200 m) off the east coasts of North and South Islands throughout the year, including East Cape, Mahia Peninsula, Cape Palliser, and Cook Strait (Clement 2010; Berkenbusch et al. 2013). One sighting was made along the 2000-m isobath in the southern survey area, along with several other sightings on the Chatham Rise (see Torres et al. 2013b). Clement (2010) noted that in general, bottlenose dolphins in New Zealand occur closer to shore during summer and autumn, and farther offshore during winter. A total of 157 strandings were reported between 1970 and 2013 for New Zealand (Berkenbusch et al. 2013), including East Cape, Mahia Peninsula, and Cook Strait (Brabyn 1991; Clement 2010).

As sightings have been made near the proposed study areas during the austral autumn, it is likely that bottlenose dolphins would be encountered during the survey during May–June.

Short-beaked Common Dolphin (*Delphinus delphis*)

The common dolphin is found in tropical and warm temperate oceans around the world (Jefferson et al. 2008). It ranges as far south as 40°S in the Pacific Ocean, is common in coastal waters 200–300 m deep and is also associated with prominent underwater topography, such as seamounts (Evans 1994). Neumann (2001) noted that this species can be found in coastal and oceanic habitats.

Short-beaked common dolphins are found in shelf waters of New Zealand, generally north of Stewart Island; they are more commonly seen in waters along the northeastern coast of North Island (Stockin and Orams 2009; NABIS 2014) and may occur closer to shore during the summer (Neumann 2001; Stockin et al. 2008). They can be found all around New Zealand (Baker 1999) with abundance

hotspots on the east coast occurring along Northland, Hauraki Gulf, Mahia Peninsula, Cape Palliser, Cook Strait, and Marlborough Sounds (NABIS 2014).

The short-beaked common dolphin is likely the most common cetacean species in New Zealand waters, occurring there year-round (Clement 2010; Hutching 2013). Numerous sightings have been made in shelf waters of the east coast of North and South Islands, as well as farther offshore, throughout the year, including near and within the proposed northern, middle, and southern survey areas (Clement 2010; Berkenbusch et al. 2013). Clement (2010) reported that dense areas of sightings occur in offshore waters off East Cape and just to the south of Mahia Peninsula, especially during fall and summer. Feeding has also been observed in the shelf waters off East Cape, and calves are sighted regularly there (Clement 2010). Short-beaked common dolphins are generally seen at a mean distance of <10 km from shore in the summer, and move farther offshore in winter (Neumann 2001). In addition, 749 strandings were reported between 1950 and 2008, including records for East Cape, Hawke's Bay, and Cook Strait (Stockin and Orams 2009).

As sightings have been made near and within the survey areas during austral fall, this species could be encountered during the proposed surveys in May–June.

Hourglass Dolphin (*Lagenorhynchus cruciger*)

The hourglass dolphin occurs in all parts of the Southern Ocean south of ~45°S, with most sightings between 45°S and 60°S (Goodall 2009). Although it is pelagic, it is also sighted near banks and islands (Goodall 2009). Baker (1999) reported that the hourglass dolphin is considered a rare coastal visitor to New Zealand. Berkenbusch et al. (2013) reported five sightings of hourglass dolphins in New Zealand waters, including one off Banks Peninsula, one off the southeast coast of South Island, and three south of New Zealand; all sightings were made during November–February. In addition, there have been at least five strandings in New Zealand (Berkenbusch et al. 2013), including records for the South Island (Baker 1999).

The hourglass dolphin likely would be rare in the proposed survey area.

Dusky dolphin (*Lagenorhyncus obscurus*)

The dusky dolphin is widespread in the Southern Hemisphere, occurring in disjunct subpopulations in the waters off southern Australia, New Zealand (including some sub-Antarctic islands), central and southern South America (including the Falkland Islands), and southwestern Africa (Jefferson et al. 2008). The species occurs in coastal and continental slope waters and is uncommon in waters >2000 m deep (Würsig et al 2007). The dusky dolphin is common in New Zealand (Hutching 2013) and occurs there year-round. Dusky dolphins migrate northward to warmer waters in winter and south during the summer (Gaskin 1968).

The dusky dolphin occurs along the entire coast of South Island and the southern part of North Island, up to Hawke's Bay (Würsig et al. 2007; NABIS 2014); they are rarely seen north of East Cape (Baker 1999). Concentration hotspots include Marlborough Sounds and the northeastern coast of South Island, particularly around Kaikoura (NABIS 2014). The shallow waters around Kaikoura serve as a nursery for mother-calf pairs (Weir et al. 2008), with calving occurring between November and January (Würsig et al. 2007). Gaskin (1968) noted that they are the most common dolphin species in the Cook Strait/Banks Peninsula region. They are more often sighted around northern South Island and southern North Island waters during winter (Würsig et al. 1997).

Sightings of dusky dolphins exist for shelf as well as deep, offshore waters (Berkenbusch et al. 2013). Würsig et al. (2007) noted that dusky dolphin typically moves into deeper waters during the winter. Sightings have been made in the northern survey area, and adjacent to the middle and southern survey areas (see Clement 2010; Berkenbusch et al. 2013). Sightings in the austral fall have been made off East Cape, southeastern North Island, and northeastern South Island and Cook Strait (Berkenbusch et al. 2013). Several sightings have been made along the 500-m isobath on the Chatham Rise, south of the survey areas (Torres et al. 2013b). In addition, at least 107 strandings have been reported for New Zealand (Berkenbusch et al. 2013), including records for East Cape, Hawke's Bay, Cape Palliser, and Cook Strait (Brabyn 1991; Clement 2010).

The dusky dolphin could be encountered during the proposed surveys.

Southern Right Whale Dolphin (*Lissodelphis peronii*)

The southern right whale dolphin is distributed between the Subtropical and Antarctic Convergences in the Southern Hemisphere, generally between ~30ºS and 65ºS (Jefferson et al. 2008). It is sighted most often in cool, offshore waters, although it is sometimes seen near shore where coastal waters are deep (Jefferson et al. 2008).

The species has rarely been seen at sea in New Zealand (Baker 1999). Berkenbusch et al. (2013) reported five sightings for the EEZ of New Zealand, including one each off the southeast coast and southwest coast of South Island, and three to the southeast of Stewart Island; sightings were made during February and September. During August 1999, a group 500+ southern right whale dolphins including a calf were sighted southeast of Kaikoura in water >1500 m deep (Visser et al. 2004). There were five additional sightings in the OBIS database, including one sighting in the South Taranaki Bight, two sightings southeast of Kaikoura during 1985–1986, and two sightings off the southwest coast of South Island (OBIS 2014).

At least 16 strandings have been reported for New Zealand (Berkenbusch et al. 2013). Most strandings have occurred along the north coast of South Island (Brabyn 1991), but one stranding was also reported for Hawke's Bay (Clement 2010).

The southern right whale dolphin could be encountered during the proposed surveys.

Hector's dolphin (*Cephalorhynchus hectori*)

Hector's dolphin is endemic to New Zealand and has one of the most restricted distributions of any cetacean (Dawson and Slooten 1988); it occurs in New Zealand waters year-round (Berkenbusch et al. 2013). Hector's dolphin (*C. h. hectori*) occurs around South Island, and Maui's dolphin (*C. h. maui*) is restricted to the northern west coast of North Island (Baker et al. 2002). Occasional sightings are made off the eastern coast of North Island (Berkenbusch et al. 2013), but it is unknown whether these individuals are from the South Island or the North island populations (Clement 2010).

There are at least three genetically separate populations off South Island: off the east coast (particularly around Banks Peninsula); off the west coast; and off the Southland coast (Baker et al. 2002). Hector's dolphins occur in coastal waters (Slooten et al. 2006). During summer on the east coast around Banks Peninsula, Hector's dolphins tend to aggregate in shallow waters close to shore. During winter, the distribution extends farther offshore, up to 33 km on shallow shelf areas (Rayment et al. 2006; Slooten et al. 2005). In general, Hector's dolphins prefer waters <90 m deep (Bräger et al. 2003; Rayment et al. 2006; Slooten et al. 2006) within 10 km from shore (Hutching 2013). However, several offshore sightings have also been made, including off Mahia and Banks Peninsula (Berkenbusch et al. 2013), with

the farthest sighting at 60 km from shore (Hutching 2013). Sightings have been made in shallow (<100 m) water adjacent to the northern, middle, and southern survey areas (Berkenbusch et al. 2013). In addition, there have been at least 249 strandings of Hector's dolphin in New Zealand (Berkenbusch et al. 2013).

Habitat use modeling by Torres et al. (2013c) showed that nearshore waters adjacent to the southern survey area on the northeast coast of South Island have moderate to high habitat suitability for Hector's dolphin, at least during the winter. The highest habitat suitability occurred in shallow, coastal waters around South Island; suspended particulate matter, dissolved organic matter, wave height, and sea surface temperature were important predictors of suitable habitat (Torres et al. 2013c).

The occurrence of Hector's dolphins in the project area during May–June likely would be rare because of their nearshore distribution.

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep, offshore waters (Odell and McClune 1999), but is also known to occur over the continental shelf and in nearshore shallow waters on occasion (Jefferson et al. 2008). In the western Pacific, the false killer whale is distributed from Japan south to Australia and New Zealand.

There have been at least 27 sightings of false killer whales in New Zealand during summer and fall, primarily along the coast of North Island, but also off South Island and in South Taranaki Bight (Berkenbusch et al. 2013). Several sightings have been reported for the Bay of Plenty, East Cape, and off northeastern South Island (Clement 2010; Berkenbusch et al. 2013). During 20 and 25 January 2011, two groups of false killer whales, consisting of 150 and 30 individuals, respectively, were seen cooperatively feeding with common bottlenose dolphins in Hauraki Gulf (Zaeschmar et al. 2013). On 25 March 2010, a group of eight killer whales was observed in the Bay of Islands attacking a group of 50–60 false killer whales that included ~15 calves (Visser et al. 2010). In addition, there have been at least 16 strandings in New Zealand (Berkenbusch et al. 2013), including East Cape, Hawke's Bay, and Cape Palliser (Brabyn 1991; Clement 2010). These strandings include a mass stranding on North Island (~37°S) of 231 whales in March 1978 (Baker 1999).

The false killer whale could be encountered during the proposed surveys.

Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters and also frequents tropical waters (Heyning and Dahlheim 1988). The killer whale has been reported to be common in New Zealand waters (Baker 1999), with a population of ~200 individuals (Suisted and Neale 2004).

Killer whales have been sighted in all months around North and South Islands (Berkenbusch et al. 2013; NABIS 2014; Torres 2012). Calves and juveniles also occur there throughout the year (Visser 2000). Only the Type A killer whale is considered resident in New Zealand, while Types B, C, and D are vagrant and most common in the Southern Ocean (Visser 2000, 2007; Baker et al. 2010). Visser (2000, 2007) suggested that there may be three killer whale subpopulations in New Zealand, including off North Island, South Island, and one population that moves between the two regions. Visser (2000) noted that the east coast of North Island appears to be an important region for North Island and North-South populations. Killer whale sightings occur within 37 km of New Zealand throughout the year, but appear

to occur more frequently off the southern part of North Island and the northernmost part of South Island from November through February (Visser 2007).

Killer whales sightings have been made in nearshore and offshore waters of New Zealand year-round, including sightings in and near the northern, middle, and southern study areas (Berkenbusch et al. 2013). Sightings have also been made in the northern study area, and off East Cape and Hawke's Bay (Clement 2010; Torres et al. 2013b). Pods of killer whales are known to frequent Wellington Harbour during the spring and summer (NZDOC 2014b). In addition, there have been at least 45 strandings of Type A killer whales in New Zealand (Berkenbusch et al. 2013).

During winter, killer whales are usually found farther offshore, up to 150 km (Clement 2010). Habitat use modeling by Torres et al. (2013c) showed that the proposed survey areas likely have average to above average habitat suitability for killer whales. Sea surface temperature was the most important habitat predictor (Torres et al. 2013c).

As sighting of killer whales have been made near and within the survey areas during the austral fall, killer whale sightings may occur in small numbers near the project area during May–June.

Short-finned (*Globicephala macrorhynchus*) and Long-finned Pilot Whales (*G. melas*)

The short-finned pilot whale is found in tropical and warm temperate waters, and the long-finned pilot whale is distributed antitropically in cold temperate waters (Olson 2009). The ranges of the two species show little overlap, but both species are known to occur off North Island, New Zealand (Olson 2009). Short-finned pilot whale distribution does not generally range south of 40°S (Jefferson et al. 2008).

Pilot whales (*Globicephala* sp.) have been sighted in the coastal and offshore waters of New Zealand year-round, including in and near the northern, middle, and southern survey areas (Berkenbusch et al. 2013). Pilot whales also commonly strand en masse in New Zealand (Baker 1999; O'Callaghan et al. 2001). There have been at least 280 strandings of long-finned pilot whales and at least 12 short-finned pilot whale strandings in New Zealand (Berkenbusch et al. 2013). Short-finned and long-finned pilot whale stranding records exist for East Cape and Hawke's Bay (Clement 2010), and strandings for long-finned pilot whales have also been reported for Cook Strait (Brabyn 1991).

Most pilot whales sighted south of ~40°S likely would be the long-finned variety; however, short-finned pilot whales could also be encountered during the survey, particularly in the northern survey area.

(3) Pinnipeds

Southern elephant seal (*Mirounga leonina*)

The southern elephant seal has a near circumpolar distribution in the Southern Hemisphere (Jefferson et al. 2008). However, the distribution of southern elephant seals does not typically extend to the proposed survey area (NABIS 2014). Breeding colonies occur on some New Zealand sub-Antarctic islands, including Antipodes and Campbell Islands (Suisted and Neale 2004); these are part of the Macquarie Island stock of southern elephant seals (Taylor and Taylor 1989). Pups are occasionally born during September–October on east coast beaches of the mainland, including the southern coast of South Island (between Oamaru and Nugget Point), Kaikoura Peninsula, and on the southeast coast of North Island (Taylor and Taylor 1989; Harcourt 2001).

Even though mainland New Zealand is not part of their regular distribution, juvenile southern elephant seals are sometimes seen over the shelf of South Island (van den Hoff et al. 2002; Field et al. 2004), including the area of the southern survey. Most sightings occur during the haul-out period in July

and August and between November and January during the molt (van den Hoff 2001). Sightings have been made on the central coast of South Island and Kaikoura Peninsula (van den Hoff 2001). Individuals have also occurred in the Bay of Plenty, Christchurch, and Gisborne (Harcourt 2001); others have been seen in Wellington and other North Island beaches (Daniel 1971).

Although possible, it is unlikely that southern elephant seals would be encountered during the proposed survey, especially during May–June.

New Zealand fur seal (***Arctocephalus forsteri***)

The New Zealand fur seal occurs throughout New Zealand waters and is the most common seal in the area (NZDOC 2014b). It can be found on rocky shores of the mainland, the Chatham Islands, and sub-Antarctic islands (NABIS 2014; NZDOC 2014b). The New Zealand fur seal population is expanding, with migrating seals colonizing new locations and haul-out sites becoming new breeding colonies (Bradshaw et al. 2000).

Large breeding colonies occur on the west and southern coast and islands around South Island; smaller colonies occur on North Island, including the east coast of Cape Palliser, and on the northeast coast of South Island (NABIS 2014). Marlborough Sounds, the Cook Strait area, and northeastern South Island are hotspots for New Zealand fur seal distribution (NABIS 2014). There are at least 15 haul-out sites and three breeding areas between Cape Palliser and Bay of Plenty, including haul out sites along Hawke's Bay (Clement 2010). There are also two haul-out sites adjacent to the southern survey area on (Taylor et al. 1995).

Pupping occurs from November to January; during this time, females stay close to breeding locations and foraging trips do not extend past the continental shelf (Harcourt et al. 1995). During autumn and winter, foraging occurs farther from the breeding sites, with trips extending more than 150 km from breeding sites, and into water depths >1000 m (Harcourt and Davis 1997; Harcourt et al. 2002).

It is likely that New Zealand fur seals would be encountered during the proposed survey, especially during May–June, when they tend to occur farther offshore.

Sea Turtles

Five species of sea turtles could occur in or near the proposed survey area. The leatherback, hawksbill, and South Pacific Distinct Population Segment (DPS) of loggerhead turtles are designated as ***endangered*** under the ESA. Breeding populations of green and olive ridley turtles on the Pacific coast of Mexico are ***endangered*** whereas all other populations are ***threatened***. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the PEIS. The general distribution of sea turtles in the western South Pacific Ocean is discussed in § 3.4.3.8 of the PEIS. The rest of this section deals specifically with their distribution within the proposed survey area off the coast of New Zealand.

Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds. It is found from 71°N to 47°S, and nesting occurs from 38°N to 34°S (Eckert et al. 2012). There are 28 nesting sites in the western Pacific Ocean, with ~5000–9200 nests annually, and 75% of nesting activity in Papua, Indonesia (Dutton et al. 2007). Other significant leatherback turtle nesting areas occur in Papua New Guinea, the Solomon Islands, and Vanuatu (Dutton et al. 2007). No major nesting sites have been reported for Australia, but a few nests have been found there

(Eckert et al. 2012). Benson et al. (2007) reported on a tagged leatherback turtle that migrated from Papua New Guinea to offshore waters east of New Zealand, at ~170 °W, before traveling north again.

Leatherback turtles are the most frequently reported sea turtle species in New Zealand, occurring throughout the waters around North and South Islands (Gill 1997; NZDOC 2014c,d). There are 92 records of live leatherbacks and 32 records of dead leatherback turtles for New Zealand (NZDOC 2014d). Records have been reported near the northern, middle, and southern survey areas, including East Cape, Hawke's Bay, and Cook Strait (see Gill 1997; NZDOC 2014d). Most records have been reported for January and February, but at least seven leatherback sea turtle specimens have been reported during May and June (Gill 1997). The waters of North Cape and the east coast of the Northland Peninsula are main foraging grounds for this species in New Zealand (NZDOC 2014c).

Leatherback turtles are taken as bycatch in the longline fishery in New Zealand (Harley and Kendrick 2006). During 2001–2005, seven leatherback turtles were captured during the fishery and released alive (Harley and Kendrick 2006). Most interactions occurred in deep, offshore waters north of the East Cape; two others were reported in waters north of North Island, and one occurred off the southwest coast of South Island (Harley and Kendrick 2006).

Migrating or foraging leatherbacks could occur in the survey area. They likely would be the most frequently encountered sea turtle because of their tolerance of cold water.

Green Turtle (*Chelonia mydas*)

The green turtle is widely distributed in tropical and subtropical waters near continental coasts and around islands. Major nesting sites in the western Pacific include Raine Island off eastern Australia, where ~25,000 females nest, Indonesia, Malaysia, and the Philippines (Shanker and Pilcher 2003; NMFS and USFWS 2007a).

Green sea turtles are the second most frequently reported sea turtle species in New Zealand (Gill 1997). They can be sighted around the Northland Peninsula, with regular occurrences at Rangaunu Harbour and Poor Knights Islands (NZDOC 2014c). There are 52 records of live green turtles and 18 records of dead green turtles for New Zealand (NZDOC 2014d), including single records adjacent to each of the northern, middle, and southern survey areas (see Gill 1997; NZDOC 2014d). The majority of records have been reported for the austral summer (January–March), but at least three green sea turtle specimens have been reported during May and June (Gill 1997). Most green turtles in New Zealand are thought to be part of the Indo/Western Pacific population, although some are from the Eastern Pacific population (NZDOC 2014c). There are also non-breeding residents at the subtropical Kermadec Islands of New Zealand (NZDOC 2014c).

Green turtles are taken as bycatch in the longline fishery in New Zealand (Harley and Kendrick 2006). During 2001–2005, one green turtle was captured and released alive and one turtle was dead (Harley and Kendrick 2006). One interaction occurred in deeper water in the northern survey and one occurred outside the EEZ, northwest of North Island (Harley and Kendrick 2006).

Loggerhead Turtle (*Caretta caretta*)

The loggerhead is a widely distributed species, occurring in coastal tropical and subtropical waters. Loggerhead turtle nesting in the Pacific Ocean is restricted to the western region; the two main nesting stocks in Japan and Australia/New Caledonia have been identified as genetically distinct (NMFS and USFWS 2007b). Loggerheads may occasionally nest on the extreme northern beaches of New Zealand (Pritchard 1982). The nesting season is typically from May to August (USFWS 2003).

Post-hatchling loggerheads from rookeries in eastern Australia or New Caledonia in the western South Pacific appear to make transoceanic migrations to areas in the southeastern Pacific Ocean (Boyle et al. 2009). En route to their destinations in the eastern Pacific, via the Tasman Front and Peruvian Current, loggerheads have been found stranded along the coast of North Island (Boyle et al. 2009). Pritchard (1982) reported that the small loggerheads found along the northern areas of New Zealand, typically in late winter, likely hatched ~6 months before on beaches in Queensland and drifted southeast to New Zealand.

Loggerhead turtles are occasional visitors to New Zealand, with records concentrated along the east coast of Northland Peninsula (NZDOC 2014c,d). There are 27 records of live loggerheads and 20 records of dead loggerhead turtles for New Zealand, including for Hawke's Bay and adjacent to the middle survey area (NZDOC 2014d). Records exist as far south as Banks Peninsula and Stewart Island (NZDOC 2014c,d). Most records have been reported for the austral winter (July–September), followed by austral summer (January–March); no reports exist for May or June, but at least three specimens have been reported during April (Gill 1997).

One loggerhead turtle was reported to have been caught alive and released during the longline fishery in New Zealand in 2002 (Harley and Kendrick 2006). This animal was taken as bycatch in the Bay of Plenty (Harley and Kendrick 2006).

Some migrating loggerhead turtles, especially juveniles, could be encountered in the proposed survey area.

Hawksbill Turtle (*Eretmochelys imbricata*)

The hawksbill is the most tropical of all sea turtles, with nesting occurring between ~30ºN and ~30ºS (Eckert 1995). In the western Pacific, major hawksbill turtle nesting areas can be found in Australia, Indonesia, Papua New Guinea, and the Philippines (NMFS and USFWS 2007c).

Hawksbill turtles rarely occur off mainland New Zealand, although they are more regularly sighted in the subtropical Kermadec Islands of New Zealand (NZDOC 2014c). There are 22 records of live hawksbill turtles and 13 records of dead turtles for New Zealand (NZDOC 2014d). Most records have been reported for the Northland Peninsula, but records also exist for East Cape, and Cape Palliser adjacent to the proposed middle survey area (Gill 1997; NZDOC 2014d). Most records have been reported for the austral winter (July–September), but at least four specimens have been reported during May and June (Gill 1997).

It is possible that some migrating hawksbill turtles could be encountered during the proposed surveys.

Olive Ridley Turtle (*Lepidochelys olivacea*)

The olive ridley has a large range in tropical and subtropical regions in the Pacific, Indian, and south Atlantic oceans, and is generally found between 40ºN and 40ºS. In the western Pacific, olive ridley turtle nesting colonies occur in Australia, Brunei, Malaysia, Indonesia, and Vietnam (Shanker and Pilcher 2003; NMFS and USFWS 2007d).

Olive ridley turtles are rare visitors to New Zealand waters (NZDOC 2014c). There are four records of live individuals and six records of dead olive ridley turtles (NZDOC 2014d). Records have been reported near North Cape, west coast of North Island, Cook Strait, southeast coast of South Island, and Stewart Island; in addition, there is a bone/fossil record for the area adjacent to the middle survey area (see NZDOC 2014d).

It is unlikely that any olive ridley turtles would be sighted during the proposed surveys.

Seabirds

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families are given in § 3.5.1 of the PEIS.

Four penguin species that are listed as ***threatened*** under the ESA are endemic to New Zealand, all occurring to the south or east of the survey areas (USFWS 2010). The New Zealand/Australia DPS of a fifth penguin species that is widely distributed around the Southern Ocean, the southern rockhopper penguin (*Eudyptes chrysocome*) is also listed as ***threatened*** (USFWS 2011). The yellow-eyed penguin (*Megadyptes antipodes*) breeds on the southeast coast of South Island, from Banks Peninsula at ~44°S to the southern tip, and on islands south of there; it forages over the continental shelf. The white-flippered penguin (*Eudyptula minor albosignata*) breeds on Banks Peninsula and on Motunau Island ~100 km to the north; birds disperse locally around eastern South Island. Breeding adults apparently remain close to nesting colonies in the nonbreeding season. The Fiordland crested penguin (*Eudyptes pachyrhynchus*) is endemic to South Island and adjacent offshore islands southwards from Bruce Bay on the west coast, and a large part of its range is in Fiordland National Park on the southwest coast and on Stewart Island just off the south coast. Outside of the breeding season, the birds have been sighted around North and South Islands and south to the sub-Antarctic islands. The erect-crested penguin (*Eudyptes sclateri*) breeds on the Bounty Islands and Antipodes Islands, located >700 km southeast of South Island. The New Zealand/Australia DPS of the southern rockhopper penguin breeds on Campbell Island, the Auckland Islands, and the Antipodes Island Group on the Campbell Plateau, >500 km to the south and east of South Island.

Two petrel species that are listed as ***endangered*** under the ESA are endemic to Chatham Island (USFWS 2009), >500 km east of Banks Peninsula. The Chatham petrel (*Pterodroma axillaris*) and magenta petrel (*Pterodroma magentae*) are pelagic, feeding in the open sea generally out of sight of land year round. During their breeding seasons (September–May and November–June, respectively), birds return to breeding colonies to nest and breed.

Two shorebirds that are listed as ***endangered*** under the ESA occur in New Zealand. The New Zealand shore plover (*Thinornis novaeseelandiae*), with a population of <200, is restricted to the Chatham Islands (Dowding 2013). The black stilt (*Himantopus novaezelandiae*) has a population size of ~100; its breeding population is confined to the Mackenzie Basin of South Canterbury and North Otago, southern South Island. Outside of the breeding season, most black stilts move locally within the Mackenzie Basin, and small numbers move to the Canterbury coast and north to Kawhia and Kaipara harbors, northwest North Island (Pierce 2013).

Fish, Essential Fish Habitat, and Habitat Areas of Particular Concern

There are no ESA-listed fish species, Essential Fish Habitat (EFH), or habitats of particular concern (HAPC) in the proposed survey area. However, the following fish and reef-building invertebrate species protected under New Zealand's government-run Conservation Services Programme may occur in or near the survey area:

- **Fish:** deepwater nurse shark, white pointer shark, whale shark, basking shark, oceanic white-tip shark, manta ray, spinetail devil ray, giant grouper, and spotted black grouper (NZDOC 2014e).
- **Black corals:** all species in the order Antipatharia; occur in 10–1000 m (primarily >200 m) water depth in or near the northern study and the middle study areas (Consalvey et al. 2006;

NZDOC 2014e,f). Collection or damage to these species is strictly prohibited (NZDOC 2014f).

- **Gorgonian corals:** all species in the order Gorgonacea; known to occur in or near the northern and middle survey areas (Consalvey et al. 2006; NZDOC 2014e).
- **Stony corals:** all species in the order Scleractinia (NZDOC 2014e).
- **Hydrocorals:** all species in the family Stylasteridae, also known as "red corals"; known to occur in or near the northern and middle survey areas (Consalvey et al. 2006; NZDOC 2014e,f). Collection or damage to these species is strictly prohibited (NZDOC 2014f).

The New Zealand Government employs various tools to provide targeted protection of specific habitats or species that are not comprehensive enough to qualify as MPAs, including marine mammal sanctuaries, marine parks, Mätaitai reserves (marine reserves for traditional Maori fishing grounds, developed and managed by local iwi (tribes)/hapü (clans) with the Ministry for Primary Industries [MPI]), Taiäpure (traditional Maori fishing grounds, including areas of special cultural/spiritual significance, established by the MPI), benthic protection areas, and areas of significant conservation value (regionally-managed coastal areas designated by local authorities) (New Zealand Government 2008a,b; NZDOC 2014g); see Figure 1. None of these areas is near the proposed survey areas.

Fisheries

The 2002-2006 commercial fisheries information described below is from all water depths in the New Zealand EEZ (SAUP 2011); May and June 2013–2014 commercial fisheries information is from NABIS (2014). Other sources used here are the Ministry for Primary Industries (MPI 2010; 2013a,b; 2014b,c,d), Statistics NZ (2010), the Pegasus Basin 2D Marine Seismic Survey Environmental Impact Assessment (ERM 2014), the East Coast and Pegasus Multiclient 2D Marine Seismic Survey Marine Mammal Impact Assessment (EOS 2014), and fishing tournament information from The Fishing Website (2014).

(1) Commercial Fisheries

There are 130 commercially fished species in New Zealand fisheries, 97 of which are managed under the Quota Management System (MPI 2013a). The major species targeted in commercial fisheries include squid, hoki (blue grenadier), ling, oreo dories, orange roughy, silver warehou, spiny rock lobster, paua, and snapper (MPI 2013a). During 1996–2009 (with 2009 being the most recent year available with a published Fish Monetary Stock Account), the top five most valuable commercial fisheries species were consistently hoki, rock lobster, paua, orange roughy, and snapper, in order of decreasing total value (Statistics NZ 2010). Of these five species, hoki comprised the greatest catch in terms of total catch weight (21,044 t) in May–June 2014, followed by rock lobster (1471 t), snapper (1077 t), and orange roughy (392 t); no paua were taken (NABIS 2014). NABIS (2014) indicated the distribution of New Zealand commercial catch during this time, presented as weight ranges within management units (Fig. 3). Relative to the proposed survey areas, the majority of hoki were captured in the vicinity of the southern survey, followed by the middle and northern survey areas, respectively. Rock lobsters were equally taken in the shallowest portions of all three proposed survey areas. No orange roughy were reliably reported in the survey areas, with the exception of a very small portion of the southeastern northern survey area in 2014. Snapper catches were only reported in the western half of the northern survey area, although they were among the highest catch weight range.

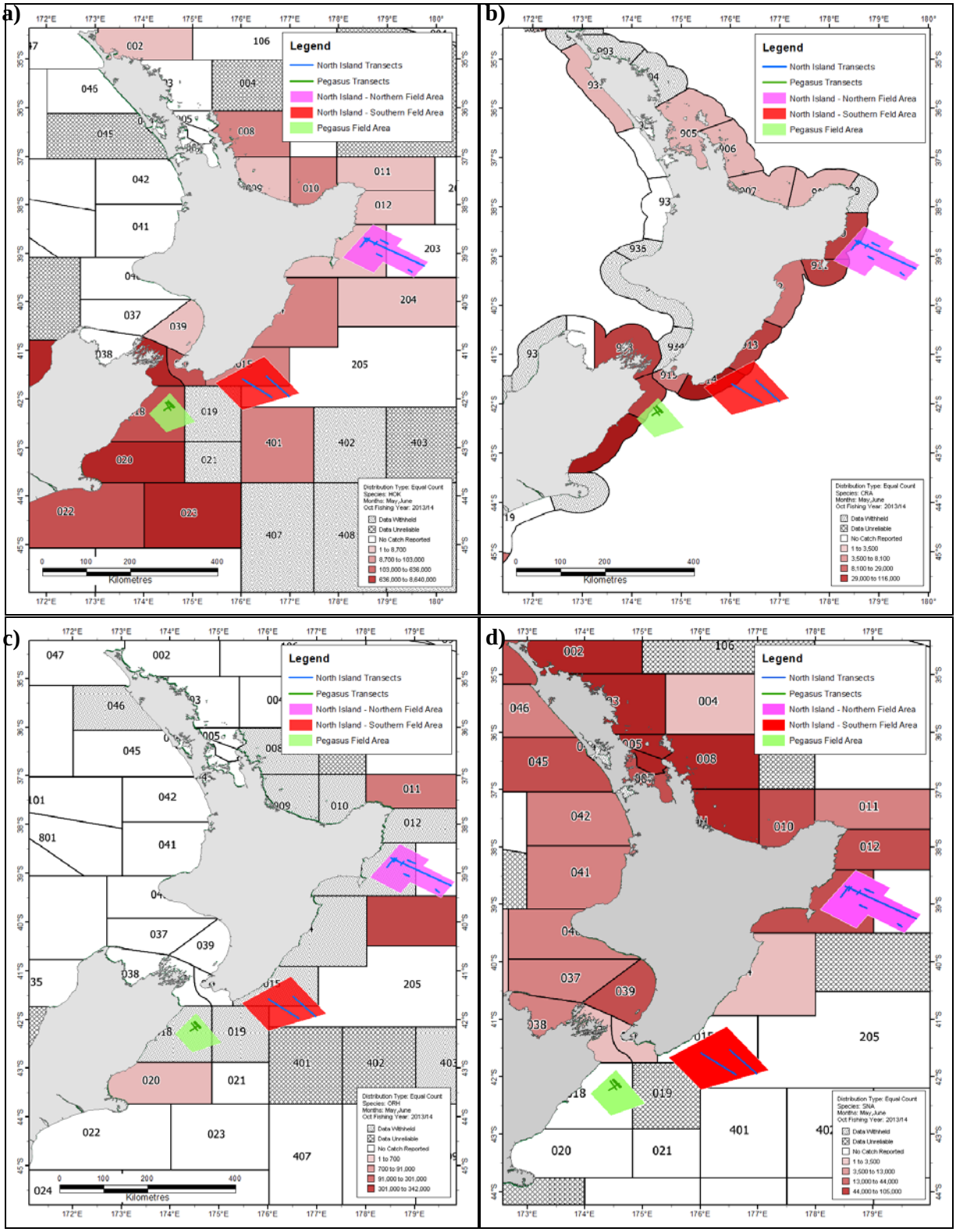

FIGURE 3. Distribution of Total Catch (kg) in the New Zealand commercial fisheries in May–June 2014 of a) hoki, b) rock lobster, c) orange roughy, and d) snapper. Source: NABIS 2014.

The total aggregated catch was 2,323,422 t during 2002–2006, with catch values 405,683–502,629 t per year (SAUP 2011). Commercial fishery catches during 2002–2006 were dominated by hoki (31% of total), "mixed group" (25%), and Wellington flying squid (14%), followed by jack and horse mackerels (7%), southern blue whiting (6%), snoek (5%), oreos (3%), pink cusk-eel (3%), orange roughy (2%), squirefish (1%), terakihi (1%), and New Zealand dredge oyster (<1%) (SAUP 2011). All of the catch was taken by New Zealand (SAUP 2011). The most predominant gear types in the New Zealand EEZ are bottom trawls and squid hooks, comprising ~64% and 14% of the total catch during 2002–2006, respectively, with lesser components (≤4% each) of hooks/gorges, mid-water trawls, gillnets, handlines, boat seines, dredges, traps, set lines, longline tuna, and "other gears" (SAUP 2011).

(2) Recreational Fisheries

The MPI is the governing body for establishing and enforcing recreational fishing rules, with the goal of maintaining sustainable fisheries (MPI 2014a). Recreational fishers are not currently required to report recreational catches of managed species, rendering it difficult to track the recreational harvest of marine fish in New Zealand (ERM 2014). There is currently insufficient data to value recreational fisheries; however, recreational harvest accounts for a significant portion of the total annual harvest for some stocks (Statistics NZ 2009 *in* ERM 2013). By 2010, an estimated 25,000 t were taken annually in recreational fisheries (MPI 2010). Effective from 30 September 2014–2015, the total allowable catch across all species in recreational fisheries decreased to 12,128 t (MPI 2014b).

Popular species targeted during recreational fisheries include kingfish, kahawai, trumpeter, trevally, tarakihi, blue moki, snapper, groper, paua (blackfoot), butterfish, john dory, red moki, rock lobster (crayfish), blue cod, red cod, red gurnard, flounder, sea perch, catfish, eels, crabs, oysters, sea urchins, green mussels, cockles, pipi, and scallops (MPI 2013b, 2014b).

In May 2014, the nearest recreational fishing tournament to any of the proposed survey areas occurred in Hawke's Bay, west of the northern survey area (The Fishing Website 2014). In June 2014, one tournament, the Discount Fishing Supplies Winter Contest, was hosted by Gisborne-Tatapouri Sports Fishing Club Inc. from Gisborne, located in the northern survey area (The Fishing Website 2014). No fishing tournaments occurred near the study areas in May or June 2013 (The Fishing Website 2014). The majority of fishing tournaments occurred in the northern/northwestern/western regions of North Island in May and June 2013–2014 (The Fishing Website 2014).

Given the distance from shore, recreational fishing is not expected to occur near the survey areas.

(3) Customary Fisheries

Fisheries are a traditional source of economic and cultural wealth for the Maori people of New Zealand (MPI 2014c). Providing fish or shellfish to feed whanau (family) or manuhiri (guests) is part of the cultural heritage of tangata whenua (people of the land) (MPI 2014d). The Kaimoana Customary Fishing Regulations (1998) and the Fisheries (South Island Customary Fishing) Regulations (1998) allow iwi and hapü to manage their non-commercial fishing in order to best fit their local practices, without major effects on the fishing rights of others (MPI 2014d). Annual total catch limits set by the government allow for this customary use of fisheries (MPI 2014d). Iwi and hapü groups decide who will act as guardians for fishing areas (Tangata Kaitaki in the North and Chatham Islands, Tangata Tiaki in the South and Stewart Islands), with the guardians then appointed by the Minister of Fisheries (MPI 2014d). Rohe Moana are areas where Kaitiaki are appointed to manage customary food gathering under the Kaimoana Customary Fishing Regulations (1998) (EOS 2014). Rohe Moana can encompass both marine and

freshwaters (FTB 2009), and several extend into the offshore (Fig. 1). Kaitiaki and Tiaki can issue anyone a permit to catch fish in their area for traditional use (with catches reported to the Ministry of Fisheries to allow for traditional use when the following year's catch limits are set), and can ask for special management areas (Mätaitai reserves and Taiäpure-local fisheries) to cover some of their traditional fishing grounds (MPI 2014d). Commercial fishing is prohibited within a Mätaitai reserve, although recreational fishing is allowed (Govier 2014). A Taiäpure does not stop all fishing, but rather allows Tangata to be involved in the management of both commercial and non-commercial fisheries in their area (Govier 2014).

Highly valued marine fish and invertebrate species taken in customary fisheries include snapper, kahawai, blue cod, flatfish, small sharks, grey mullet, sea urchin (kina), scallops, mussels, paua, pipi, toheroa, cockles, and tuatua (MPI 2014d *in* Govier 2014). No data are currently available on customary fishing harvests (ERM 2014); however, in 2010 the customary take provided for in the TAC was 4813 t, which decreased to 4608 t in the 2014–2015 fishing year (MPI 2010, 2014c).

IV. Environmental Consequences

Proposed Action

(1) Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a brief summary of the anticipated potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles, and reference to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.4.1, § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.

This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys scheduled to occur during May–June 2015, along with a description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 μPa_{rms}. Acoustic modeling for the proposed action was conducted by L-DEO, consistent with past EAs and determined to be acceptable by NMFS for use in the calculation of estimated takes under the MMPA

(a) Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, and § 3.7.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Recent research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman 2013). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect.

Although the possibility cannot be entirely excluded, it is unlikely that the project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter the surveys while they are underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance.—Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

Masking.—Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2013), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2013) reported that ambient noise levels between seismic pulses were elevated because of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2013) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Klinck et al. (2012) also found reverberation effects between airgun pulses. Nieukirk et al. (2012) and Blackwell et al. (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the seismic pulses (e.g., Nieukirk et al. 2012). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could have been disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. We are not aware of any information concerning masking of hearing in sea turtles.

Disturbance Reactions.—Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), NRC (2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m. Studies examining the behavioral responses of humpback whales to airguns are currently underway off eastern Australia (Cato et al. 2011, 2012, 2013).

In the Northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related fecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011) also reported that sound could be a potential source of stress for marine mammals.

Results from *bowhead whales* show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources (e.g., Miller et al. 2005). Nonetheless, Robertson et al. (2013) showed that bowheads on their summer feeding grounds showed subtle but statistically significant changes in surfacing–respiration–dive cycles during exposure to seismic sounds, including shorter surfacing intervals, shorter dives, and decreased number of blows per surface interval.

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses; Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 μPa. Thus, bowhead whales in the Beaufort Sea apparently decrease their calling rates in response to seismic operations, although movement out of the area could also contribute to the lower call detection rate (Blackwell et al. 2013).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

Reactions of migrating and feeding (but not wintering) *gray whales* to seismic surveys have been studied. Off St. Lawrence Island in the northern Bering Sea, it was estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1 μPa_{rms} (Malme et al. 1986, 1988). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al. 1984; Malme and Miles 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (e.g., Gailey et al. 2007; Johnson et al. 2007; Yazvenko et al. 2007a,b).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses; sightings by observers on seismic vessels off the U.K. from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were operating vs. silent, although there was localized avoidance (Stone and Tasker 2006). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with versus without airgun sounds (Castellote et al. 2012).

During seismic surveys in the Northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year, and bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Toothed Whales

Little systematic information is available on reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information on responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

During seismic surveys in the Northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* (*Monodon monoceros*) in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005).

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010), but foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009). There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). However, some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005). In any event, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly.

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa; sound exposure levels or SELs of 145–151 dB $\mu Pa^2 \cdot s$); however, animals returned to the area within a few hours. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans.

Sea Turtles

The limited available data indicate that sea turtles hear airgun sounds and sometimes exhibit localized avoidance (see PEIS, § 3.4.4.3). Based on available data, it is likely that sea turtles would exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate are likely to have the greatest impact. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of year.

Hearing Impairment and Other Physical Effects.—Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds. However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would

occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy, although there is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy. Frequency, duration of the exposure and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Finneran 2012; Ketten 2012; Kastelein et al. 2013a).

The assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (SEL) is probably an oversimplification (Finneran 2012). Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 μPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Kastelein et al. (2012a,b; 2013b) also reported that the equal-energy model is not valid for predicting TTS in harbor porpoises or harbor seals.

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Schlundt et al. (2013) reported that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, Finneran et al. (2011) and Schlundt et al. (2013) reported no measurable TTS in bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of ~195 dB re 1 $\mu Pa^2 \cdot s$; results from auditory evoked potential measurements were more variable (Schlundt et al. 2013).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013a). Popov et al. (2013b) also reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Therefore, Supin et al. (2013) reported that SEL may not be a valid metric for examining fatiguing sounds on beluga whales. Similarly, Nachtigall and Supin (2013) reported that false killer whales are able to change their hearing sensation levels when exposed to loud sounds, such as warning signals or echolocation sounds.

It is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans (*cf.* Southall et al. 2007). Some cetaceans could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga or bottlenose dolphin. Based on the best available information, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1 $\mu Pa^2 \cdot s$. Tougaard et al. (2013) proposed a TTS criterion of 165 dB re 1 $\mu Pa^2 \cdot s$ for porpoises based on data from two recent studies. Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose closest point of approach to a seismic vessel is 1 km or more could experience TTS.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the likelihood that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels ≥180 dB and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). The proposed exclusion (shut-down) zones planned for the proposed seismic surveys are considered to be more conservative than distances based on these criteria. Those criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In December 2013, NOAA made available for public comment new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2013), taking at least some of the Southall et al. recommendations into account. The new acoustic guidance and procedures could account for the now-available scientific data on marine mammal TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive (e.g., M-weighting or generalized frequency weightings for various groups of marine mammals, allowing for their functional bandwidths), and other relevant factors. At the time of preparation of this Final EA, the date of release of the final guidelines and how they would be implemented are unknown.

Nowacek et al. (2013) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong transient sounds.

There is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. However, Gray and Van Waerebeek (2011) have suggested a cause-

effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. Additionally, a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (e.g., Castellote and Llorens 2013).

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

There is substantial overlap in the frequencies that sea turtles detect vs. the frequencies in airgun pulses. We are not aware of measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds similar to airgun pulses. In the absence of relevant absolute threshold data, we cannot estimate how far away an airgun array might be audible. Moein et al. (1994) and Lenhardt (2002) reported TTS for loggerhead turtles exposed to many airgun pulses (see PEIS). This suggests that sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs. However, exposure duration during the proposed surveys would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

The PSOs stationed on the *Revelle* would also watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

(b) Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES, Knudsen Chirp 3260 SBP, and pinger would be operated from the source vessel during the proposed survey, but not during transits. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the anticipated potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel (ISRP) linking the operation of a MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other

factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. The proposed survey design and environmental context of the proposed survey are quite different from the mass melon-headed whale stranding described by the ISRP. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of a MBES. It is noted that leading scientific experts knowledgeable about MBES have expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including Low-Frequency Active (LFA) sonars (e.g., Miller et al. 2012; Sivle et al. 2012) and Mid-Frequency Active (MFA) sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012; DeRuiter et al. 2013a,b; Goldbogen et al. 2013). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during Ocean Acoustic Waveguide Remote Sensing (OAWRS) activities that were carried out ~200 km away. The OAWRS used three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz with received levels in the sanctuary of 88–110 dB re 1 μPa. Deng et al (2014) measured the spectral properties of pulses transmitted by three 200-kHz echo sounders, and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels.

Despite the aforementioned information that has recently become available, this Final EA is in agreement with the assessment presented in § 3.4.7, 3.6.7, and 3.7.7 of the PEIS that operation of MBESs, SBPs, and pingers is not likely to impact mysticetes or odontocetes, and is not expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

(c) Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals and/or sea turtles include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear.

Vessel noise from the *Revelle* could affect marine animals in the proposed survey area. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995). Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Hatch et

al. 2012). In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012; Castellote et al. 2012; Melcón et al. 2012: Tyack and Janik 2013).

Baleen whales are thought to be more sensitive to sound at low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed survey area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found that humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels. Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar-Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

The PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals or sea turtles, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles. Information on vessel strikes is reviewed in § 3.4.4.4 and § 3.6.4.4 of the PEIS. The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel.

Entanglement of sea turtles in seismic gear is also a concern. There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007), and in April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on the R/V *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are not possible with the pair of GI guns that would be towed by the *Revelle*. Also, towing the hydrophone streamer or other equipment during the proposed survey is not expected to significantly interfere with sea turtle movements, including migration, because sea turtles are not expected to be abundant in the survey areas.

(2) Mitigation Measures

Several mitigation measures are built into the proposed seismic surveys as an integral part of the planned activities. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups during the day; and shut downs when mammals or turtles are

detected in or about to enter designated EZ. These mitigation measures are described in § 2.4.4.1 of the PEIS and summarized earlier in this document, in § II(3). The fact that the GI airguns, as a result of their design, direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

Previous and subsequent analysis of the potential impacts takes account of these planned mitigation measures. It would not be meaningful to analyze the effects of the planned activities without mitigation, as the mitigation (and associated monitoring) measures are a basic part of the activities, and would be implemented under the Proposed Action or Alternative Action.

(3) Potential Numbers of Cetaceans Exposed to Received Sound Levels ≥160 dB

All anticipated takes would be "takes by harassment" as described in § I, involving temporary changes in behavior. The mitigation measures to be applied would minimize the possibility of injurious takes. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to sound levels >160 dB re 1 μPa_{rms} and present estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The estimates are based on consideration of the number of marine mammals that could be disturbed by ~1250 km of seismic surveys east of New Zealand. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

(a) Basis for Estimating Exposure

The estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where the received levels (RLs) of sound >160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates are likely to overestimate the numbers actually exposed to the specified level of sounds. The overestimation is expected to be particularly large when dealing with the higher sound-level criteria, e.g., 180 dB re 1 μPa_{rms}, as animals are more likely to move away before RL reaches 180 dB than they are to move away before it reaches (for example) 160 dB re 1 μPa_{rms}. Likewise, they are less likely to approach within the ≥180 dB re 1 μPa_{rms} radius than they are to approach within the considerably larger ≥160 dB radius.

To our knowledge, no systematic aircraft- or ship-based surveys have been conducted for marine mammals in offshore waters of the South Pacific Ocean east of New Zealand. For most cetacean species, we used densities from extensive NMFS SWFSC cruises (Ferguson and Barlow 2001, 2003; Barlow 2003, 2010; Forney 2007) in one province of Longhurst's (2006) pelagic biogeography, the California Current Province (CALC). That province is similar to the South Subtropical Convergence Province (SSTC) in which the proposed surveys are located, in that productivity is high and large pelagic fish such as tuna occur. Specifically, we used the 1986–1996 data from blocks 35, 36, 47, 48, 59, and 60 of Ferguson and Barlow (2001, 2003), the 2001 data from Barlow (2003) for the OR/WA and CA strata, and the 2005 and 2008 data from Forney (2007) and Barlow (2010), respectively, for the two strata combined. The densities used were effort-weighted means for the 10 locations (blocks or States). The surveys off CA, OR, and WA were conducted up to ~556 km offshore, and most of those data were from offshore areas that overlap with the above blocks selected from Ferguson and Barlow (2001, 2003).

For pinnipeds, we used the densities in Bonnell et al. (1992) of northern fur seals and northern elephant seals in offshore areas of western U.S. (the only species regularly present in offshore areas there) to estimate the numbers of pinnipeds that might be present off New Zealand.

The species that would be encountered during the proposed survey would be different from those sighted during the surveys off the western U.S. and in the ETP. However, the overall abundances of species groups with generally similar habitat requirements are expected to be roughly similar. Thus, we used the data described above to estimate the group densities of beaked whales, delphinids, small whales, and mysticetes in the proposed survey area. We then estimated the relative abundance of individual southern species within the species groups using various surveys and other information from areas near the study area, and general information on species' distributions such as latitudinal ranges and group sizes. Group densities from northern species were multiplied by their estimated relative abundance off New Zealand divided by the relative abundance for all species in the species group to derive estimated for the southern species (Table 4).

Densities for several cetacean species are available for the Southern Ocean (Butterworth et al. 1994), as follows: (1) for humpback, sei, fin, blue, sperm, killer, and pilot whales in Antarctic Management areas I–VI south of 60°S, based on the 1978/79–1984/84 and 1985/86–1990/91 IWC/IDCR circumpolar sighting survey cruises, and (2) for humpback, sei, fin, blue, and sperm whales extrapolated to latitudes 30–40°S, 40–50°S, 50–60°S based on Japanese scouting vessel data from 1965/66–1977/78 and 1978/79–1987/88. We calculated densities based on abundances and surface areas given in Butterworth et al. (1994) and used the mean density for the more recent surveys and the 30–40°S and 40–50°S strata because the survey areas are between ~38°S and 43°S.

The estimated numbers of individuals potentially exposed presented below are based on the 160-dB re 1 μPa_{rms} criterion for all cetaceans. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 5 shows the density estimates described above and the estimates of the number of different individual marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic surveys if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 5.

It should be noted that the following estimates of exposures to various sound levels assume that the proposed surveys would be completed; in fact, the ensonified areas calculated using the planned number of line-kilometers ***have been increased by 25%*** to accommodate turns, lines that may need to be repeated, equipment testing, etc. As is typical during offshore ship surveys, inclement weather and equipment malfunctions are likely to cause delays and may limit the number of useful line-kilometers of seismic operations that can be undertaken. Also, any marine mammal sightings within or near the designated EZ would result in the shut down of seismic operations as a mitigation measure. Thus, the following estimates of the numbers of marine mammals potentially exposed to 160-dB re 1 μPa_{rms} sounds are precautionary and probably overestimate the actual numbers of marine mammals that could be involved. These estimates assume that there would be no weather, equipment, or mitigation delays, which is highly unlikely.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and "Summary of Potential Airgun Effects" of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the following estimates are based, was developed based primarily on data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids given below are thus considered precautionary. New criteria for behavioral harassment based on dose-response-type curves or risk functions are being considered by

TABLE 4. Densities of marine mammal species groups sighted during surveys off the west coast of the US during 1986–2008, densities of cetaceans in the Southern Ocean between 30°S and 50°S, and estimated densities of species expected to occur during the SIO seismic surveys off eastern New Zealand during May–June 2015. Densities are derived as described in the text. Species listed as endangered are in italics.

Species	Observed density off US west coast (#/1000 km^2)	Relative abundance off New Zealand	Estimated density off New Zealand (#/1000 km^2)	Density in the Southern Ocean, 30-50°S, 1978/79–1987/88 (#/1000 km^2)
Mysticetes				
Southern right whale		*5*	*0.98*	
Pygmy right whale		2	0.39	
Humpback whale		*5*	*0.98*	*0.01*
Antarctic minke whale		3	0.59	
Dwarf minke whale		3	0.59	
Bryde's whale		1	0.20	
Sei whale		*3*	*0.59*	*0.07*
Fin whale		*3*	*0.59*	*0.10*
Blue whale		*3*	*0.59*	*0.02*
All mysticetes	**5.47**			
Odontocetes				
Physeteridae				
Sperm whale		*5*	*1.62*	*1.74*
Pygmy sperm whale		3	*0.97*	
All sperm whales	**2.58**			
Ziphiidae				
Southern bottlenose whale		2	0.46	
Cuvier's beaked whale		3	0.69	
Shepard's beaked whale		2	0.46	
Andrew's beaked whale		2	0.46	
Blainville's beaked whale		1	0.23	
Gray's beaked whale		4	0.92	
Hector's beaked whale		2	0.46	
Spade-toothed whale		1	0.23	
Strap-toothed whale		3	0.69	
All Beaked whales	**4.59**			
Delphinidae				
Bottlenose dolphin		5	81.55	
Short-beaked common dolphin		10	163.10	
Hourglass dolphin		3	48.93	
Dusky dolphin		5	81.55	
Southern right-whale dolphin		3	48.93	
Hector's dolphin		2	32.62	
All Dolphins	**456.69**			
False killer whale		3	0.27	
Killer whale		5	0.45	
Short-finned pilot whale		3	0.27	
Long-finned pilot whale		5	0.45	
All small whales	**1.46**			
Pinnipeds				
Southern elephant seal		*2*	5.11	
New Zealand fur seal		*5*	12.79	
All Pinnipeds	**17.90**			

TABLE 5. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 dB re 1 μPa_{rms} during SIO's proposed seismic surveys east of New Zealand during May–June 2015. The proposed sound source consists of two 45-in^3 GI guns. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level B "takes" for which authorization is requested.

Species	Estimated Density (#/1000 km^2) based on US west coast	Reported Density (#/1000 km^2) in Southern Ocean	Estimated Density (#/1000 km^2)	Enson-ified Area (km^2)	Calculated Take[1]	% of Regional Pop'n[2]	Requested Level B Take Author-ization
Mysticetes							
Southern right whale	*0.98*		*0.98*	1154	*1*	*0.01*	*1*
Pygmy right whale	0.39		0.39	1154	0	N/A	0
Humpback whale	*0.98*	*0.01*	*0.01*	1154	*1*	*<0.01*	*1*
Antarctic minke whale	0.59		0.59	1154	1	<0.01	1
Dwarf minke whale	0.59		0.59	1154	1	<0.01	1
Bryde's whale	0.20		0.20	1154	0	<0.01	0
Sei whale	*0.59*	*0.07*	*0.07*	1154	*0*	*<0.01*	*0*
Fin whale	*0.59*	*0.10*	*0.10*	1154	*0*	*<0.01*	*0*
Blue whale	*0.59*	*0.02*	*0.02*	1154	*0*	*<0.01*	*0*
Odontocetes							
Sperm whale	*1.62*	*1.74*	*1.74*	1154	*2*	*0.01*	*2*
Pygmy sperm whale	*0.97*		*0.97*	1154	1	N/A	1
Southern bottlenose whale	0.46		0.46	1154	1	<0.01	1
Cuvier's beaked whale	0.69		0.69	1154	1	<0.01	1
Shepard's beaked whale	0.46		0.46	1154	1	<0.01	1
Andrew's beaked whale	0.46		0.46	1154	1	<0.01	1
Blainville's beaked whale	0.23		0.23	1154	0	<0.01	0
Gray's beaked whale	0.92		0.92	1154	1	<0.01	1
Hector's beaked whale	0.46		0.46	1154	1	<0.01	1
Spade-toothed whale	0.23		0.23	1154	0	<0.01	0
Strap-toothed whale	0.69		0.69	1154	1	<0.01	1
Bottlenose dolphin	81.55		81.55	1154	94	N/A	94
Short-beaked common dolphin	163.10		163.10	1154	188	N/A	188
Hourglass dolphin	48.93		48.93	1154	56	<0.01	56
Dusky dolphin	81.55		81.55	1154	94	N/A	94
Southern right-whale dolphin	48.93		48.93	1154	56	N/A	56
Hector's dolphin	32.62		32.62	1154	38	<0.01	38
False killer whale	0.27		0.27	1154	0	N/A	0
Killer whale	0.45		0.45	1154	1	N/A	1
Long-finned pilot whale	0.27		0.27	1154	0	<0.01	0
Short-finned pilot whale	0.45		0.45	1154	1	N/A	1
Pinnipeds							
Southern elephant seal	5.11		5.11	1154	6	0.01	6
New Zealand fur seal	12.79		12.79	1154	15	<0.01	15

[1] Calculated take is estimated density (reported density x correction factor) multiplied by the 160-dB ensonified area (including the 25% contingency)

[2] Requested takes expressed as percentages of the regional populations in New Zealand, the Southern Hemisphere, or Antarctic (Table 3); N/A means not available

NMFS. Available data suggest that the current use of a 160-dB criterion may be improved upon, as behavioral response may not occur for some percentage of odontocetes and mysticetes exposed to received levels >160 dB, while other individuals or groups may respond in a manner considered as taken to sound levels <160 dB (NMFS 2013). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013).

(b) Potential Number of Marine Mammals Exposed

The number of different individuals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} on one or more occasions can be estimated by considering the total marine area that would be within the 160-dB radius around the operating seismic source on at least one occasion, along with the expected density of animals in the area. The number of possible exposures (including repeated exposures of the same individuals) can be estimated by considering the total marine area that would be within the 160-dB radius around the operating airguns, including areas of overlap. During the proposed surveys, the transect lines are widely spaced relative to the 160-dB distance. Thus, the area including overlap is 1.13 x the area excluding overlap, so a marine mammal that stayed in the survey area during the entire survey could be exposed slightly more than once, on average. However, it is unlikely that a particular animal would stay in the area during the entire survey. The numbers of different individuals potentially exposed to ≥160 dB re 1 μPa_{rms} were calculated by multiplying the expected species density times the anticipated area to be ensonified to that level during airgun operations excluding overlap. The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160-dB buffer (see Table 1) around each seismic line, and then calculating the total area within the buffers.

Applying the approach described above, ~923 km^2 (~1153.6 km^2 including the 25% contingency) would be within the 160-dB isopleth on one or more occasions during the proposed surveys. Because this approach does not allow for turnover in the mammal populations in the area during the course of the surveys, the actual number of individuals exposed may be underestimated, although the conservative (i.e., probably overestimated) line-kilometer distances used to calculate the area may offset this. Also, the approach assumes that no cetaceans would move away or toward the trackline as the *Revelle* approaches in response to increasing sound levels before the levels reach 160 dB. Another way of interpreting the estimates that follow is that they represent the number of individuals that are expected (in the absence of a seismic program) to occur in the waters that would be exposed to ≥160 dB re 1 μPa_{rms}.

The estimates of the numbers of individual cetaceans and pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} during the proposed surveys are 545 and 21, respectively (Table 5). That total includes seven cetaceans listed as ***Endangered*** under the ESA: the southern right, humpback, sei, fin, and blue whales (1 each or 0.01% or less of the regional populations) and the sperm whale (2 or 0.01% of the regional population).

In addition, seven beaked whales could be exposed during the surveys (Table 5). Most (96.9%) of the cetaceans potentially exposed are delphinids; the common dolphin, bottlenose dolphin, and dusky dolphin are estimated to be the most common delphinid species in the area, with estimates of 188 (estimate of regional population size not available), 94 (estimate of regional population size not available), and 94 (0.59% of regional population) exposed to ≥160 dB re 1 μPa_{rms}, respectively.

Two pinnipeds species could be exposed during the surveys: the New Zealand fur seal and the southern elephant seal, with estimates of 15 (<0.01% of the regional population) and 6 (0.01%), respectively.

(4) Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing a very small source, a pair of 45-in^3 GI airguns that introduce pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

(a) Cetaceans

In § 3.6.7, 3.7.7, and 3.8.7, the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some mysticete and odontocete species in the Sub-antarctic QAA, and that Level B behavioral effects were possible but unlikely for pinnipeds; that Level A effects were highly unlikely; and that operations were unlikely to adversely affect ESA-listed species.

In this Draft EA, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the regional population sizes (Table 5). The estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The reasons for that conclusion are outlined above. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on cetaceans would be anticipated from the proposed activities.

(b) Sea Turtles

In § 3.4.7, the PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. Five species of sea turtle—the leatherback, loggerhead, green, hawksbill, and olive ridley—could be encountered in the proposed survey area. Only foraging or migrating individuals would occur. Given the proposed activities, no significant impacts on sea turtles would be anticipated.

(5) Direct Effects on Invertebrates, Fish, Fisheries, and EFH and Their Significance

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations, fisheries, and associated EFH. Furthermore, there are no ESA-listed fish species or EFH in the proposed survey area.

Approximately 20 deployments of a core sampler would be made in total. The core samplers are either piston corers with a 10-cm diameter barrel, gravity corers with a 10-cm diameter barrel, or a multicorer with 8 core sampling tubes ~10 cm in diameter. Also, ~200 heat-flow measurements would be made using a probe ~6 cm in diameter. Although coring operations would disrupt a very small area of seafloor habitat and could disturb benthic invertebrates, the impacts are expected to be localized and transitory. There are no HAPCs in the in the waters of the survey area.

Given the proposed activities, no significant impacts on marine invertebrates, marine fish, and commercial, recreational, or customary fisheries would be anticipated.

(6) Direct Effects on Seabirds and Their Significance

Effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. Given the proposed activities, no significant impacts on seabirds would be anticipated.

(7) Indirect Effects on Marine Mammals, Sea Turtles, and Their Significance

The proposed seismic operations would not result in any permanent impact on habitats used by marine mammals or sea turtles, or to the food sources they use. The main impact issue associated with the proposed activities would be temporarily elevated noise levels and the associated direct effects on marine mammals and sea turtles, as discussed above.

During the proposed seismic surveys, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates, if any, would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed surveys would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned.

The cables used to lower the core samplers are under tension, so the possibility of entanglement would be unlikely, if not impossible.

(8) Cumulative Effects

The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research. However, the PEIS also stated that, "A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the area of the proposed seismic surveys that may result in cumulative impacts to environmental resources." Here we focus on activities that could impact animals specifically in the proposed survey area (academic and industry research activities, vessel traffic, tourism, and fisheries).

(a) Past and future research activities in the area

Barnes et al. (2010) noted that numerous MCS surveys have been conducted over the continental shelf and slope of the Hikurangi Margin off the east coast of North Island. More recent MCS surveys that have been conducted include those by the R/V *Tangaroa* off Hawke's Bay and Mahia Peninsula during 1998–2004 (e.g., Paquet et al. 2009), the 2001 *Geco Resolution* survey off Hawke's Bay using a 8238-in^3 array (e.g., Pecher et al. 2004), the 2005 M/V *Multiwave* survey along the upper margin off Hawke's Bay that obtained 2800 km of MCS data using a 3840–4140 in^3 source array (e.g., Barker et al. 2009), and 710 km of MCS profiles by the R/V *Sonne* in 2007 along the central part of the margin, using a source array of up to 2080 in^3 (Barnes et al. 2010). In addition, 1350 km of MCS surveys were conducted in October 2011 off the northern margin (Barnes et al. 2011), and during the austral summer of 2009–2010, 2800 km of MCS data were collected in the Pegasus Basin supplemented by ocean bottom seismograph

(OBS) data (Henrys et al. 2013). Recent multibeam bathymetry and sidescan sonar surveys have also taken place in the area (Mountjoy et al. 2009; Greinert et al. 2010).

The proposed survey area is also the focus of a future IODP drilling transect that would intersect the source area of slow-slip earthquakes. The IODP project would highlight the physics behind the slow slip event processes and improve our understanding of great subduction thrust earthquakes. The project would consist of seven shallow riserless holes to recover sediments, rocks and pore fluids, to collect geophysical logs, and make downhole measurements. Borehole observatories will also be installed in a subset of these boreholes. An OBS project for the area has also been funded. An OBS array was deployed in the austral summer of 2014, and instruments will be retrieved during March–April 2015. The OBS project is part of an onshore and offshore seismic and geodetic study of shallow slow slip events at the Hikurangi subduction margin. In addition, the Hikurangi Trough has also been identified as a new site for research under the Geodynamic Processes at Rifting and Subducting Margins program (GeoPRISMS 2013), with an objective to address the subduction cycles and deformation and could include seismic surveys.

Other scientific research activities may be conducted in this region in the future; however, no other marine geophysical surveys are proposed in the region using the *Revelle* in the foreseeable future. At the present time, the proponents of the surveys are not aware of other similar research activities planned to occur in the proposed survey area during the May–June 2015 timeframe, but research activities planned by other entities are possible.

(b) Industry research activities

In addition to academic seismic surveys, numerous industry seismic surveys for oil and gas development have taken place in the vicinity. Schlumberger Seaco Inc. conducted a 2-D seismic survey in the East Coast and Pegasus Basins off the east coast of the North Island during April–May 2014; the survey used an array of 6300 in^3 and collected data along 5000 line km (EOS 2014). The Anadarko New Zealand Company also conducted a seismic survey in the Pegasus Basin during the austral summer of 2014 (ERM 2014). Both surveys overlapped the proposed middle survey area off North Island, and the Anadarko survey also occurred within the proposed southern survey area off northeastern South Island. Additionally, numerous other industry seismic surveys have taken place within the waters of New Zealand, including in the Taranaki, Canterbury, and Great South basins (NZDOC 2014h). Statoil has recently acquired an exploration permit in the Reinga Basin offshore Northland's west coast and plans to conduct a seismic survey there during the austral summer of 2014–2015 (Statoil 2013). The very small energy source that would be used to produce only a negligible increase in sound introduced to the sea by the industry surveys, all of which used much larger sources.

(c) Vessel traffic

Vessel traffic in and around the proposed survey areas would primarily or possibly exclusively consist of commercial shipping and commercial fishing vessels. Based on data made available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard, up to 14 commercial vessels per month passed near the proposed survey areas during 2007–2013 (2013 data are available for January–June, the most recent data available as of October 2014) (USCG 2013). Live vessel traffic information is available from MarineTraffic (2014), including vessel names, types, flags, positions, and destinations. Various types of vessels were in the general vicinity of the proposed survey areas when Marine Traffic (2014) was accessed on 23 and 27 October 2014, including cargo vessels (10), tankers (2), tugs (3), barge (1), fishing vessel (1), and an unidentified vessel (1). The only vessels with a flag other than New Zealand were seven of the cargo vessels and the tankers.

There are 16 Customs ports in New Zealand, serving recreational, commercial, and cruise vessels (NZCS 2011). One Customs port, Eastland Port, is in Gisborne, along the western edge of the northern survey area. At least 92% of the region's exports leave via Eastland Port, including logs, squash, processed timber products and kiwifruit; other vessels handled at this port include Royal New Zealand Navy ships, cement carriers, fertilizer ships, fishing vessels, cruise ships and recreational boats (Eastland Group 2010). Otherwise, the nearest Customs ports are in Napier, Wellington, and Picton (northern South Island, 80 km northwest of the southern survey area).

There are no precautionary areas (where ships must navigate with particular caution to reduce the risk of maritime casualty and marine pollution) near the proposed survey areas (Maritime NZ 2007). There are also no major liner shipping routes near the survey areas (Melbourne IT 2014). The majority of vessels accessing east coast New Zealand ports would have origins or destinations either in New Zealand or nearby countries (e.g., Australia, Japan, Korea, Singapore); therefore, the most travelled routes would be within the 12-n.mi. limit north or south along the coast (ERM 2014), inshore of the survey transects.

The total transit distance (~2000 km) by SIO's vessel *Revelle* would be minimal relative to total transit length for vessels operating in the proposed survey area during May–June. Thus, the combination of SIO's operations with the existing shipping operations is expected to produce only a negligible increase in overall ship disturbance effects on marine mammals.

(d) Tourism

Various companies offer whale and dolphin watching and/or interaction tours around New Zealand, although none were found to be operating in the proposed survey areas. The nearest popular whale-watching area is Kaikoura, ~35 km southwest of the southern survey area (Richter et al. 2006; Lundquist et al. 2012). There, dusky dolphins are the primary focus of dolphin-watching and swim-with-dolphin programs, although sperm whales are also viewed (Lundquist et al. 2012). Other popular whale watching/interacting tours are based out of Porpoise Bay (southeastern South Island), Doubtful Sound (southwestern South Island), Akoroa Harbour (eastern South Island), Auckland (northwestern North Island), and Bay of Islands and Hauraki Gulf (northeastern North Island; northwest of the northern survey area) (New Zealand Tourism n.d.; Orams 2004; Stockin et al. 2008). Dolphin watching tours also occur in the Bay of Plenty (Neumann 2001). Whale watching vessels typically include catamarans (e.g., Whale Watch 2014) or yachts (e.g., Auckland Tourism 2014), with some tourism companies also employing the use of fixed-wing aircraft (e.g., Wings Over Whales 2007) or helicopters (Richter et al. 2006; Lundquist et al. 2012). Flights are typically 30–50 min in duration, with an average of two to three trips per day (Richter et al. 2006). Boat-based tours are offered year-round and typically last for 2.5–3 h, ranging from 3 up to 16 trips per day during the peak summer season (Richter et al. 2006). A permit from the NZDOC is required to conduct commercial whale watching, specifying the focal species and number of trips undertaken per week (Richter et al. 2006).

In Hauraki Gulf, two dolphin tourism boats operate throughout the year (Stockin et al. 2008). According to Stockin et al. (2008), foraging and resting bouts of common dolphins were significantly disrupted by tourism boats, with both types of behaviors decreasing during boat presence. Similar behavioral changes because of tourism operations have been reported for humpback and sperm whales, and dusky, common, Hector's, and bottlenose dolphins. Other effects observed in New Zealand include variations in vocalizations, increase in dive intervals and aerial behavior, horizontal avoidance, increase in speed, and decrease in resting behavior (Stockin et al. 2008). Possible effects that tourism may have on marine mammals have also been reported (e.g., Orams 2004; Richter et al. 2006; Lundquist et al. 2012).

SIO's operations are not located in areas used for whale-watching activities and are short in duration (~one month), whereas whale watching is ongoing. The combination of the proposed surveys with the existing tourism operations is expected to produce only a negligible increase in overall disturbance effects on marine mammals.

(e) Fisheries

Fisheries in the general area of the proposed surveys are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve direct removal of prey items, noise, potential entanglement (Reeves et al. 2003), and the direct and indirect removal of prey items. There may be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area. SIO's operations in the proposed survey area are also limited (duration of ~1 month), consisting mostly of transit, and the combination of SIO's operations with the existing fishing operations is expected to produce only a negligible increase in overall disturbance effects on marine mammals and sea turtles. Proposed survey operations should not impede fishing operations, and the *Revelle* would avoid fishing vessels when towing seismic equipment. Operation of the *Revelle*, therefore, would not be expected to significantly impact recreational, customary, or commercial fishing operations in the area.

(9) Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed survey area would be limited to short-term, localized changes in behavior of individuals. For cetaceans, some of the changes in behavior may be sufficient to fall within the MMPA definition of "Level B Harassment" (behavioral disturbance; no serious injury or mortality). TTS, if it occurs, would be limited to a few individuals, is a temporary phenomenon that does not involve injury and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

(10) Coordination with Other Agencies and Processes

This Draft EA was prepared by LGL on behalf of SIO and NSF pursuant to Executive Order 12114. Potential impacts to endangered species and critical habitat have also been assessed in the document; therefore, it will be used to support the ESA Section 7 consultation process with NMFS and USFWS. This document will also be used as supporting documentation for an IHA application submitted by SIO to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for this proposed seismic project.

On behalf of SIO, the U.S. State Department will seek authorization to work within the EEZ of New Zealand and will adhere to any requirements identified through that process. SIO and NSF have reviewed the "Code of Conduct for minimising acoustic disturbance to marine mammals from seismic survey operations" issued by New Zealand. Under the Code, the proposed seismic survey would be considered a Level 3 survey: a small seismic source of with capacity less than 2.49 litres/150 in^3. Level 3 surveys are exempt from the provisions of the Code.

Alternative Action: Another Time

An alternative to issuing the IHA for the period requested, and to conducting the Project then, is to issue the IHA for another time, and to conduct the project at that alternative time. The proposed dates for

the cruise (~1 month in May–June) are the dates when the personnel and equipment essential to meet the overall project objectives are available.

Marine mammals and sea turtles are expected to be found throughout the proposed survey area and throughout the time period during which the project would occur. Most marine mammal species are probably year-round residents in the survey area, so altering the timing of the proposed project likely would result in no net benefits for any species (see § III, above).

No Action Alternative

An alternative to conducting the proposed activities is the "No Action" alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activities; however, valuable data about the marine environment would be lost. Research that would contribute to the understanding of the thermal structure of the Hikurangi subduction zone would not be gained. The No Action Alternative would not meet the purpose and need for the proposed activities.

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