Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Southwest Pacific Ocean, 2017/2018

submitted by

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to

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SUMMARY

Researchers from California State Polytechnic University (Cal Poly), California Institute of Technology (Caltech), Pennsylvania State University (Penn State), University Southern California (USC), University of Southern Mississippi (USM), University of Hawaii at Manoa (UH), University of Texas (UT), and University of Wisconsin Madison (UW), with funding from the U.S. National Science Foundation (NSF), propose to conduct three high-energy seismic surveys from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*) in the waters of New Zealand in the southwest Pacific Ocean in 2017/2018. The NSF-owned *Langseth* is operated by Columbia University's Lamont-Doherty Earth Observatory (L-DEO). One proposed seismic survey would occur east of North Island and would use an 18-airgun towed array with a total discharge volume of ~3300 in^3. Two other proposed seismic surveys (one off the east coast of North Island and one south of South Island) would use a 36-airgun towed array with a discharge volume of ~6600 in^3. The surveys would take place within the Exclusive Economic Zone (EEZ) and Territorial Waters of New Zealand in water depths ~50 to >5000 m. This request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371(a)(5).

Numerous species of marine mammals inhabit the waters of New Zealand. Several of these species are listed as ***Endangered*** under the ESA: the southern right, sei, fin, blue, and sperm whales. In addition, the two subspecies of Hector's dolphin (i.e., Maui's dolphin and South Island Hector's dolphin) are proposed for listing as ***Endangered***. Other marine ESA-listed species that could occur in the area include the ***Endangered*** leatherback, hawksbill, and loggerhead (South Pacific Distinct Population Segment or DPS) turtles; the ***Endangered*** Chatham and magenta petrels, New Zealand shore plover, and black stilt; the ***Threatened*** green (Southwest Pacific DPS) and olive ridley turtles; and the ***Threatened*** yellow-eyed, white-flippered, Fiordland crested, erect-crested, and rock hopper penguins. The oceanic white tip shark and giant manta ray that are proposed as ***Threatened***, and the Pacific bluefin tuna that is a candidate species for ESA-listing, could also occur in the proposed survey areas.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests", are set forth below. They include descriptions of the specific operations to be conducted, the marine mammals occurring in the survey areas, proposed measures to mitigate against any potential injurious effects on marine mammals, and a plan to monitor any behavioral effects of the operations on those marine mammals.

I. OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

Overview of the Activity

The proposed study consists of three surveys off the coast of New Zealand in the southwest Pacific Ocean—two off the east coast of North Island and one off the south coast of South Island. The seismic surveys being proposed include: (1) a two-dimensional (2-D) survey along the Hikurangi margin off North Island, (2) a deep penetrating three-dimensional (3-D) seismic reflection acquisition over a 15 × 60 km area offshore at the Hikurangi trench and forearc off North Island, and (3) a 2-D survey along the Puysegur margin off South Island. The proposed North Island 2-D survey would occur within ~37–43°S between 180°E and the east coast of North Island, and the proposed North Island 3-D survey would occur within ~38–39.5°S, ~178–179.5°E (Fig. 1). The proposed South Island 2-D survey would occur within ~163–168°E between 50°S and the south coast of South Island (Fig. 2).

Representative survey tracklines are shown in Figures 1 and 2; however, some deviation in actual track lines could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Water depths in the proposed survey areas range from ~50 to >5000 m. The proposed seismic surveys would be conducted within the EEZ of New Zealand, and only a small proportion of the surveys would take place in Territorial Waters. For the North Island 3-D, North Island 2-D, and South Island 2-D surveys, ~1%, ~9%, and 6%, respectively, would take place in Territorial Waters.

The North Island 2-D survey would consist of ~35 days of seismic operations plus ~2 days of transit and towed equipment deployment/retrieval. The *Langseth* would depart Auckland on ~26 October and arrive in Wellington on 1 December 2017. The North Island 3-D survey is proposed for ~5 January–8 February 2018 and would consist of ~33 days of seismic operations plus ~2 days of transit and towed equipment deployment/retrieval. The *Langseth* would leave and return to port in Napier. The South Island 2-D survey is proposed for ~15 February–15 March 2018 and would consist of ~22 days of seismic operations, ~3 days of transit, and ~7 days of ocean bottom seismometer (OBS) deployment/retrieval. The *Langseth* would leave and return to port in Dunedin.

The main goal of the ***North Island 3-D survey*** proposed by UT, UW, and UH is to determine what conditions are associated with slow slip behavior, how they differ from conditions associated with subduction zones that generate great earthquakes, and what controls the development of slow-slip faults instead of earthquake prone faults. It would enable the acquisition of 3-D seismic images and attributes that would provide an unprecedented opportunity to accurately document the structural, stratigraphic, and hydrogeologic conditions that lead to generation of slow slip events (SSEs) along a subduction megathrust.

To achieve the project goals of the North Island 3-D survey, the Principal Investigator (PI) Dr. N. Bangs (UT) along with the co-PIs Drs. K. McIntosh (UT), G. Moore (UH), and H. Tobin (UW) propose to use multi-channel seismic (MCS) surveys to acquire 3-D seismic reflection data in a 15 × 60 km area offshore New Zealand's Hikurangi trench and forearc. Although not funded through NSF, international collaborators Drs. S. Henrys (GNS Science), S. Kodaira (Japan Agency for Marine-Earth Science and Technology or JAMSTEC), and R. Bell (Imperial College London) would work with the PIs to achieve the research goals, providing assistance, such as through logistical support and data acquisition and exchange. This international collaborative experiment would record *Langseth* shots during seismic

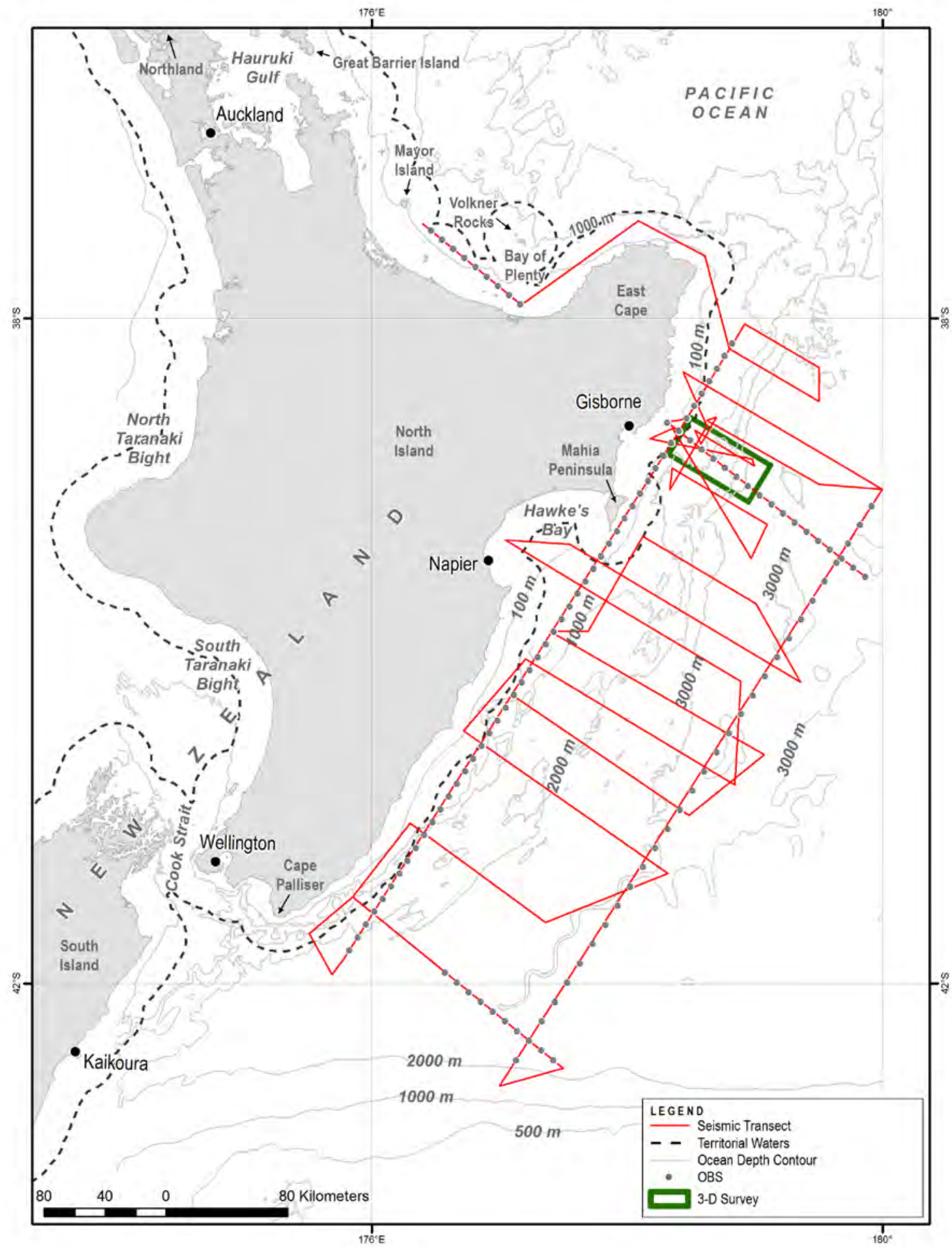

FIGURE 1. Location of the proposed 2017/2018 3-D and 2-D seismic surveys off New Zealand's North Island in the southwest Pacific Ocean.

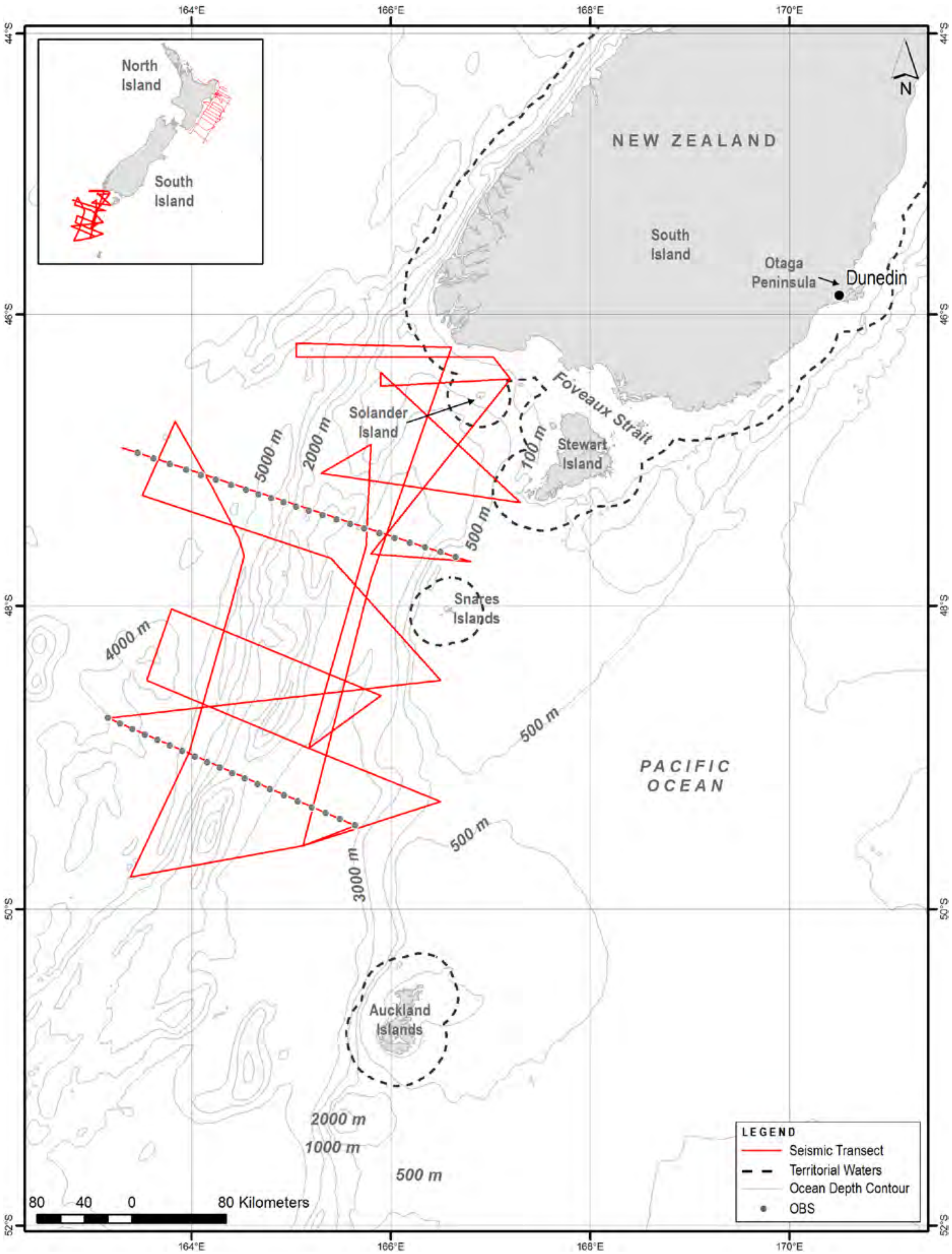

FIGURE 2. Location of the proposed 2018 2-D seismic survey off New Zealand's South Island in the southwest Pacific Ocean.

acquisition and develop the first ever high-resolution 3-D velocity models across a subduction zone using 3-D full-waveform inversion, overlapping and extending beyond the 3-D volume.

The main goal of the ***North Island 2-D survey*** proposed by UT, Cal Poly, USC, USM, and Penn State is to collect seismic data to create images of the plate boundary fault zone and to show other faults and folding of the upper New Zealand plate and the underlying Pacific plate. The data would improve our understanding of why the different parts of the same plate boundary are behaving so differently to produce SSEs and large stick-slip earthquakes. Furthermore, a better understanding of what causes the differences may help New Zealand government agencies in their efforts to mitigate danger posed by earthquakes in this area.

To achieve the project goals of the North Island 2-D survey, the PIs Drs. K. McIntosh (UT), J. Marshall (Cal Poly), D. Okaya (USC), J. Pilarczyk (USM), and D. Saffer (Penn State), together with co-PIs Drs. H. van Avendonk and L. Wallace (UT), and C. Proctor (UT) propose to use MCS reflection surveys and seismic refraction data recorded by ocean-bottom seismometers (OBSs) to characterize the incoming Hikurangi Plateau, the seaward portion of the accretionary prism, and document subducted sediment variations. The project also includes an onshore/offshore seismic component. A total of 90 short-period seismometers would be deployed on the Raukumara Peninsula on private and forestry lands, in consultation with land owners, including ~45 PASSCAL instruments in a linear array and ~45 instruments off the line; seismometers would be of the model Reftek130. The land seismometers would record seismic energy from the R/V *Langseth* during the North Island 2-D and 3-D surveys and would remain in place for three to four months to also record earthquakes. This instrumentation allows for very deep seismic sampling of the Hikurangi Subduction system to determine the structure of the upper plate and properties of the deeper plate boundary zone. Although not funded through NSF, international collaborators S. Henrys and S. Ellis (GNS Science), P. Barnes (NIWA), S. Kodaira (JAMSTEC), H. Sato (University of Tokyo), and R. Bell (Imperial College London) would work with the PIs to achieve the research goals, providing assistance, such as through logistical support and data acquisition and exchange.

The main goal of the ***South Island 2-D survey*** proposed by Caltech and UT is to test models for the formation of new subduction zones and to measure several fundamental aspects of this poorly understood process. The Puysegur margin is a globally unique place where the causes and consequences initiating a new subduction zone can be observed. The study would strive to (1) measure the angle of the new fault which forms the new plate boundary and test ideas of how the faults form; (2) measure the thickness of the oceanic crust at the Puysegur ridge and test models of how the force from the nascent slab is transmitted into the plate; and (3) measure the nature of the faults, especially the thrust faults, on the over-riding plate and test models for how the forces on the over-riding plate change with time. In addition, the airguns would be used as a source of seismic waves that would be recorded onshore of the South Island, to test models for the tectonic evolution and nature of the shallow mantle directly below the plates.

To achieve the project goals of the South Island 2-D survey, the PI Dr. M. Gurnis (Caltech) along with the co-PIs Drs. J. Stock (Caltech), and H. Van Avendonk and S. Gulick (UT), propose to use MCS surveys to acquire a combination of 2-D MCS and refraction profiles with OBSs along the Puysegur Ridge and Trench south of South Island. Although not funded through NSF, international collaborators Drs. R. Sutherland and T. Stern (Victoria University, New Zealand) would work with the PIs to achieve the research goals, providing assistance, such as through logistical support and data acquisition and exchange. In addition, the collaborators would use land seismometers to record offshore airgun shots to determine the structure of the upper plate.

For the North Island 3-D survey, a 15 × 60 km survey area would begin at the Hikurangi trench and extend to within ~20 km of the shoreline. During the North Island 2-D survey, numerous transect lines would span an area off eastern North Island from the south coast to the Bay of Plenty. During the South Island 2-D survey, marine seismic refraction data would be collected along two east-west lines across the plate boundary. One 200-km line would cross the Puysegur Trench at 49°S, and would be occupied by 20 short-period OBSs. A second line 47.3°S would be 260 km long with 23 OBSs. MCS profiles would occur along these same two lines (thus each of the two lines would be surveyed twice) as well as in between and within ~100 km north and south of the two OBS lines.

A total of ~13,299 km of transect lines would be surveyed in the southwest Pacific Ocean off New Zealand: ~3025 km during the North Island 3-D survey, ~5398 km during the North Island 2-D survey, and ~4876 km during the South Island 2-D survey. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. During the North Island 3-D survey, 0%, 42%, and 58% of line km would take place in shallow (<100 m), intermediate (100–1000 m), and deep (>1000 m) water, respectively. For the North Island 2-D survey, 8%, 23%, and 69% of line km would take place in shallow, intermediate, and deep water, respectively. During the South Island 2-D survey, 1%, 17%, and 82% of line km would take place in shallow, intermediate, and deep water, respectively.

In addition to the operations of the airgun array, a multibeam echosounder (MBES), a sub-bottom profiler (SBP), and an Acoustic Doppler Current Profiler (ADCP) would be operated from the *Langseth* continuously during the seismic surveys, but not during transit to and from the survey areas. All planned geophysical data acquisition activities would be conducted by L-DEO with on-board assistance by the scientists who have proposed the studies. The vessel would be self-contained, and the crew would live aboard the vessel.

Source Vessel Specifications

The R/V *Marcus G. Langseth* is described in § 2.2.2.1 of the Final Programmatic Environmental Impact Statement (PEIS)/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 vessel speed during seismic operations would be 4.3–4.5 kt (~8 km/h).

Airgun Description

During the two 2-D surveys, the *Langseth* would tow the full array, consisting of four strings with 36 airguns (plus 4 spares) and a total volume of ~6600 in^3. During the North Island 3-D survey, the *Langseth* would tow two separate 18-airgun arrays that would fire alternately; each array would have a total discharge volume of ~3300 in^3. The airgun arrays are described in § 2.2.3.1 of the PEIS, and the airgun configurations are illustrated in Figures 2-11 to 2-13 of the PEIS. The 4-string array would be towed at a depth of 9 m, and the shot intervals would range from 37.5 m for North Island to 50 m for South Island 2-D MCS acquisition, and 120–150 m for OBS acquisition. During the North Island 3-D survey, the arrays would be towed at a depth of 7–9 m, and the shot interval would be 37.5 m.

Predicted Sound Levels

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and safety zones (160 dB re $1\mu Pa_{rms}$) for Level B takes. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS) as a function of distance from the

18-airgun and 36-airgun arrays and for a single 1900LL 40-in^3 airgun, which would be used during power downs; all models used a 9-m tow depth. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m. Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with the 18-airgun or 36-airgun array at a maximum tow depth of 9 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS). The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the differences in tow depth between the calibration survey (6 m) and the proposed surveys (9 m); whereas the shallow water GOM may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array.

For the 36-airgun array, the 150-dB Sound Exposure Level (SEL)[1] corresponds to deep-water maximum radii of 9149 m for 9-m tow depth (Fig. 3) and 7244 m for a 6-m tow depth (Fig. 4), yielding a scaling factor of 1.26297 to be applied to the shallow-water 6-m tow depth results. Similarly, the 165 dB SEL corresponds to deep-water maximum radii of 1618 m for 9-m tow depth (Fig. 3) and 1284 m for 6-m tow depth (Fig. 4), yielding a scaling factor of 1.26. The 185 SEL corresponds to deep-water maximum radii of 155 m for 9-m tow depth (Fig. 3) and 126 m for 6-m tow depth (Fig. 4), yielding a scaling factor of 1.23. Measured 160-, 175-, and 195-dB re $1\mu Pa_{rms}$ distances in shallow water for the 36-airgun array towed at 6 m depth were 17.5 km, 2.84 km, and 0.24 km, respectively, based on a 95^{th} percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth difference between 6 and 9 m yields distances of 22,102 m, 3580 m, and 296 m for the 160-, 175-, and 195-dB sound levels.

For the 18-airgun 3300 in^3 array, the 150-dB SEL corresponds to deep-water maximum radius of 4391 m at a 9-m tow depth (Fig. 5). As noted above, the 150-dB SEL for the 6600 in^3 array at a 6-m tow depth is 7244 (Fig. 4), yielding a correction factor of 0.6061 that is applied to the shallow-water 6-m tow depth results. Similarly, the 165 dB SEL corresponds to deep-water maximum radii of 775 m for the 3300 in^3 array at a tow depth of 9-m (Fig. 5) and 1284 m for the 6600 in^3 array at a 6-m tow depth (Fig. 4), yielding a scaling factor of 0.60. The 185 dB SEL corresponds to deep-water maximum radii of 79 m for the 3300 in^3 array at a tow depth of 9-m (Fig. 5) and 126 m for the 6600 in^3 array at a 6-m tow depth (Fig. 4), yielding a scaling factor of 0.62. Measured 160-, 175-, and 195-dB re $1\mu Pa_{rms}$ distances in shallow water for the 36-airgun array towed at 6 m depth were 17.5 km, 2.84 km, and 240 m, respectively, based on a 95^{th} percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the differences in tow depth and array discharge volume yields distances of 10,607 m, 1710 m, and 150 m, respectively for the 160-, 175-, and 195-dB re $1\mu Pa_{rms}$ sound levels.

Measurements have not been reported for the single 40-in^3 airgun. L-DEO model results are used to determine the 160-dB_{rms} radius for the 40-in^3 airgun at a 9-m tow depth in deep water (Fig. 6). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results. For shallow water, a scaling of the field measurements obtained for the 36-airgun array was used: the 150-dB SEL level corresponds to a deep-water radius of 388 m for the 40-in^3 airgun at 9-m tow depth (Fig. 6) and 7244 for the 36-airgun array at 6-m tow depth (Fig. 4), yielding a scaling factor of 0.0536. Similarly, the 165-dB SEL level corresponds to a deep-water radius of 66 m for the 40-in^3 airgun at 9-m tow depth (Fig. 6) and 1284 m for the 36-airgun array at 6-m tow depth (Fig. 4), yielding a scaling factor of 0.05. The 185-dB SEL level corresponds to a deep-water radius of 7 m for the 40-in^3 airgun at 9-m tow depth (Fig. 6) and 126 m for the 36-airgun array at 6-m tow depth (Fig. 4), yielding a scaling factor of 0.05. Measured 160-, 175-, and 195-dB re $1\mu Pa_{rms}$ distances in shallow water for the 36-airgun array towed at 6-m depth were 17.5 km, 2.8 km, and 240 m, respectively, based on a 95^{th} percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the difference in array sizes and tow depths yields distances of 938 m, 142 m, and 12 m, respectively.

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[1] SEL (measured in dB re 1 $\mu Pa^2 \cdot s$) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

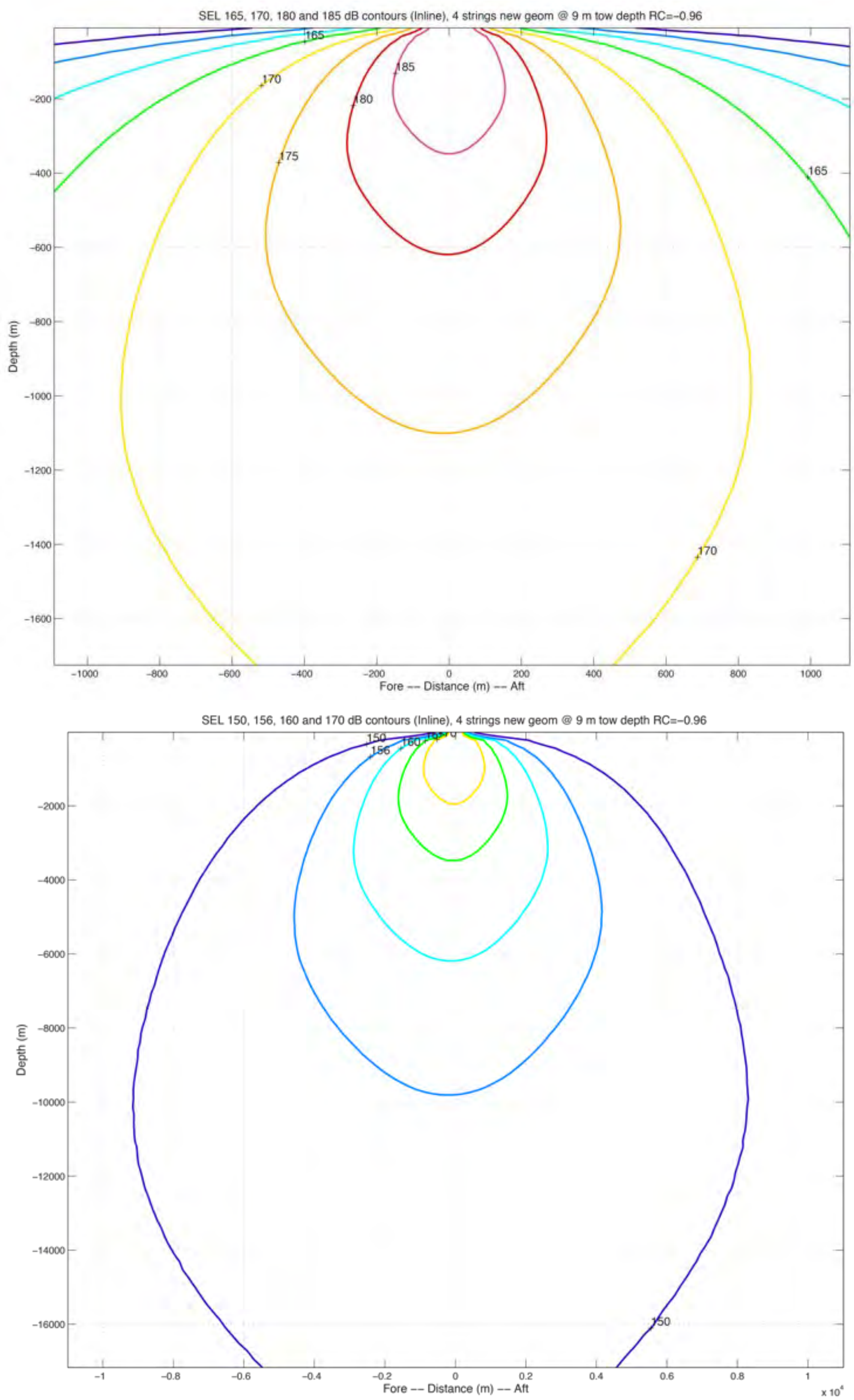

FIGURE 3. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 9-m tow depth planned for use during the proposed 2-D surveys in the southwest Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

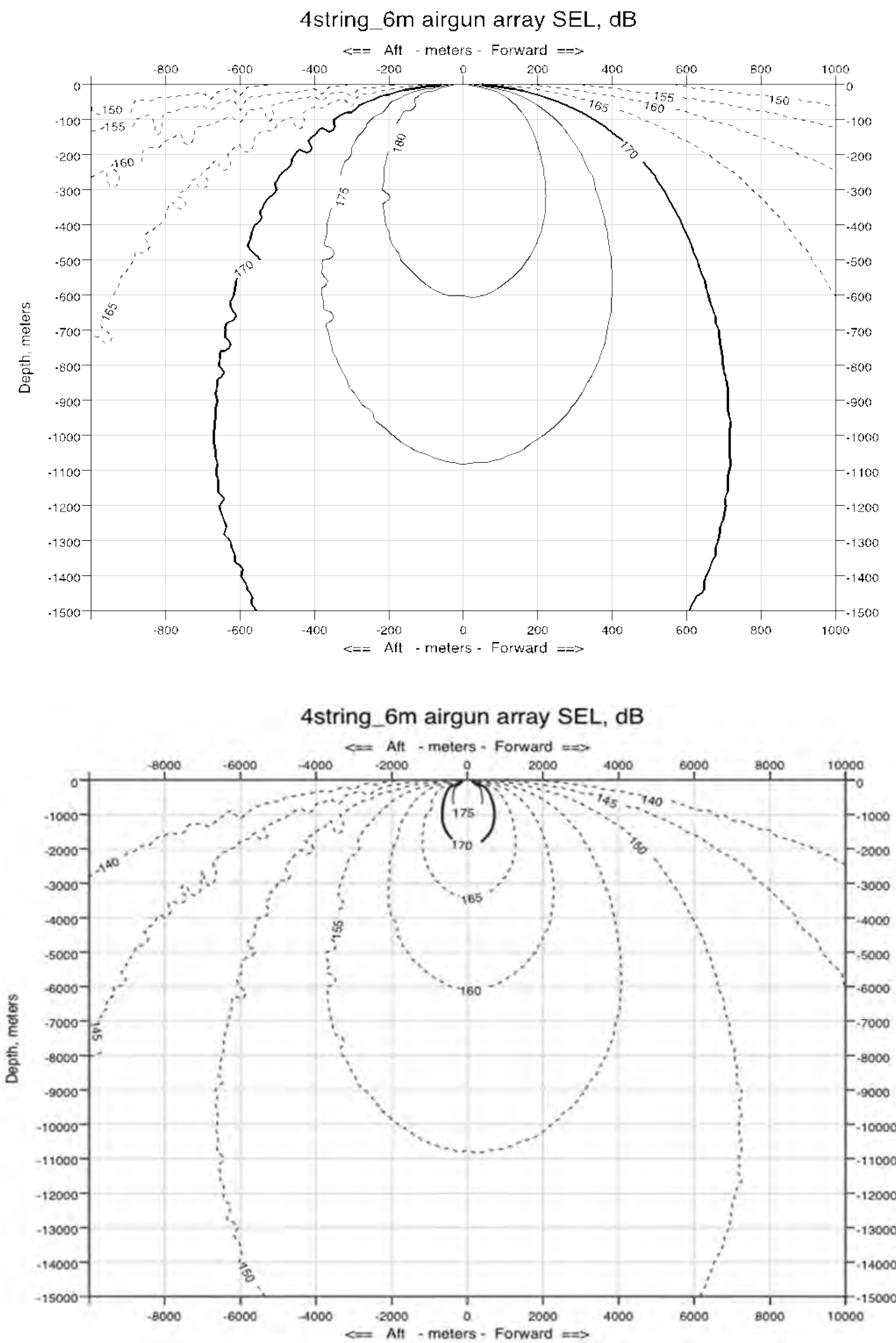

FIGURE 4. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150 dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

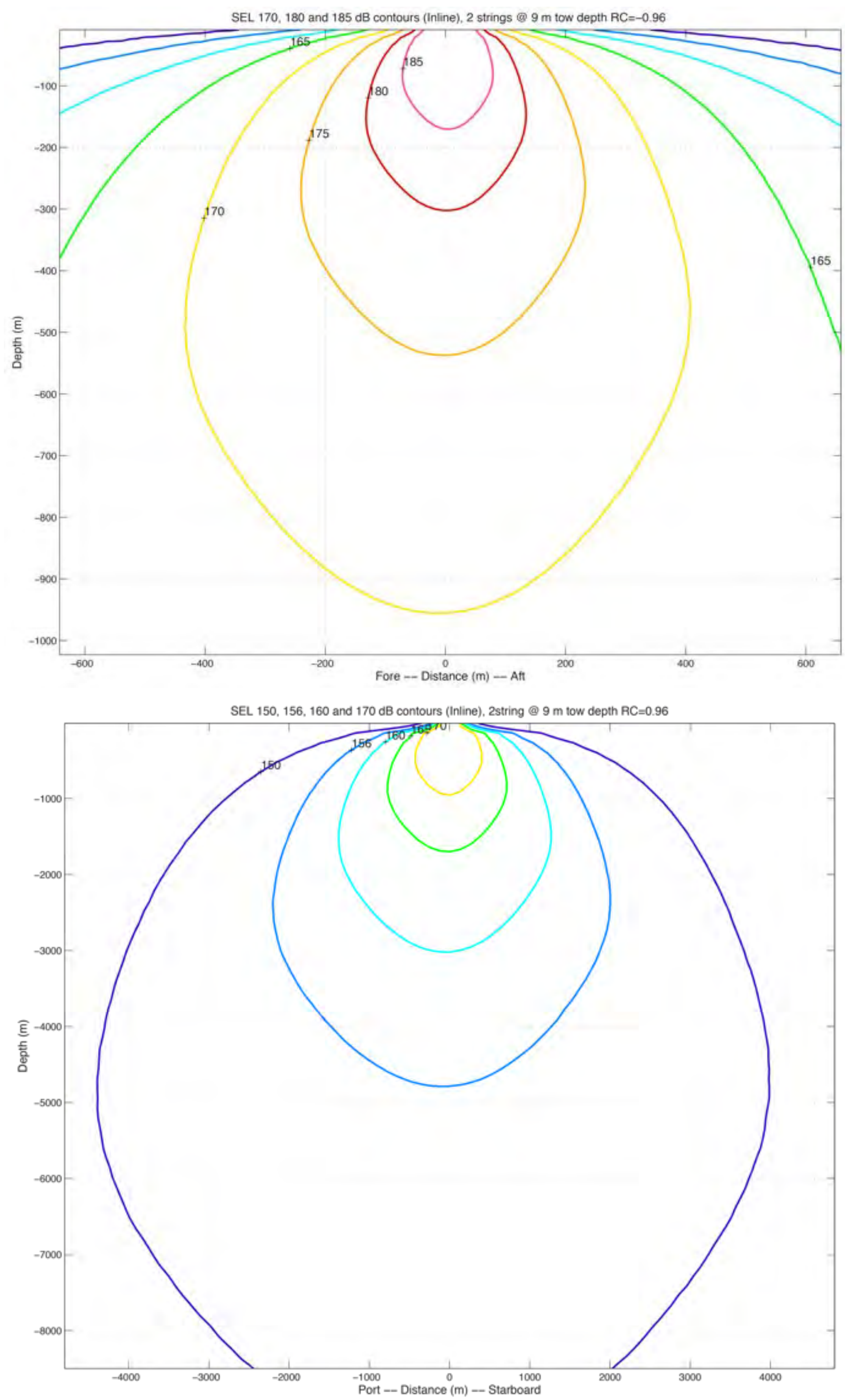

FIGURE 5. Modeled deep-water received SELs from the 18-airgun array at a 9-m tow depth planned for use during the proposed 3-D survey in the southwest Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

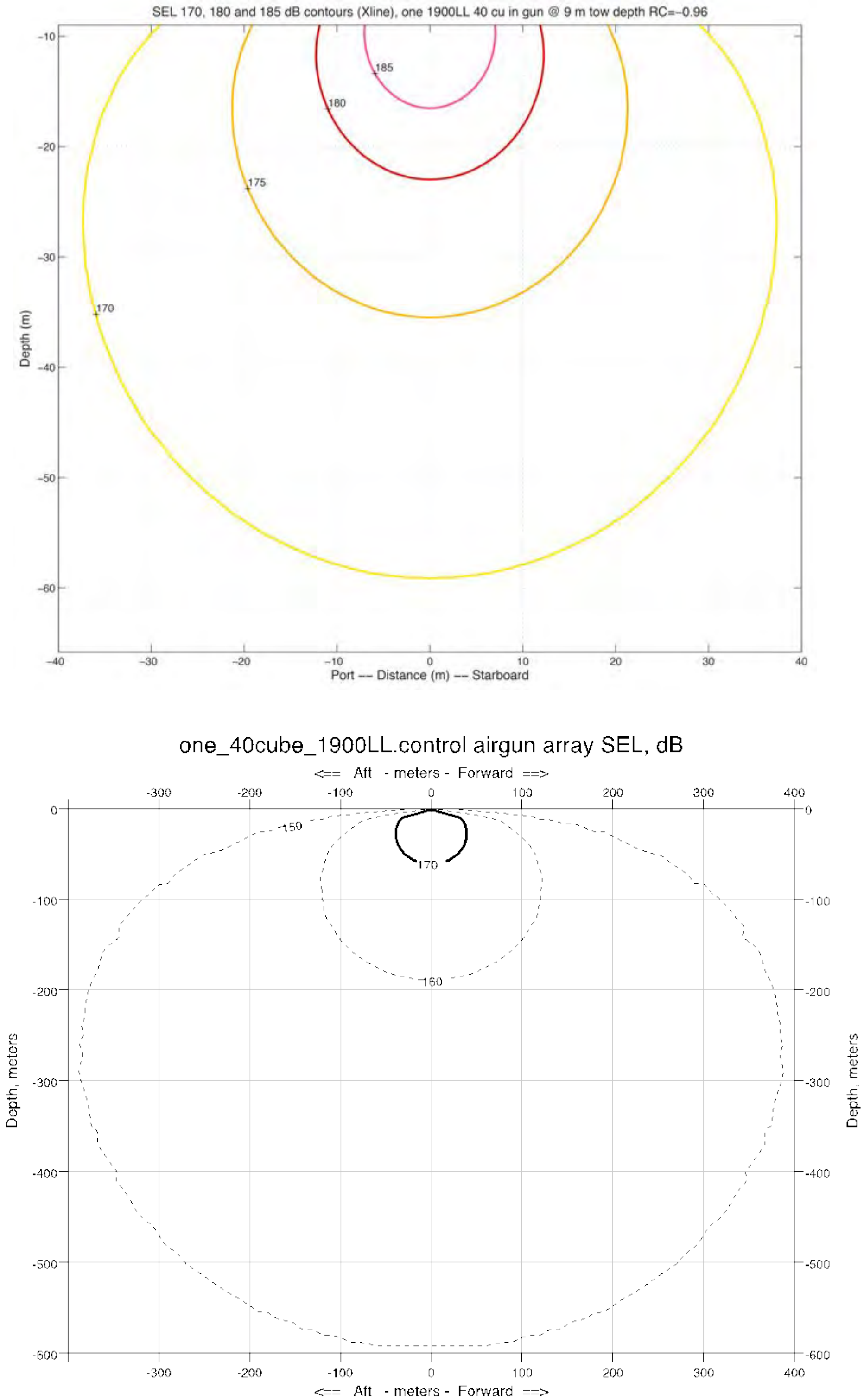

FIGURE 6. Modeled deep-water received SELs from a single 40-in^3 airgun towed at a 9-m depth, which is planned for use as a mitigation airgun during the proposed surveys in the southwest Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

Table 1 shows the distances at which the 160-dB re 1µPa_{rms} sound levels are expected to be received for the 18-airgun and 36-airgun arrays and the single (mitigation) airgun. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals. A recent retrospective analysis of acoustic propagation of *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than analysis by Crone et al. (2017) of data collected during a survey off New Jersey in 2014 and 2015 confirmed that in situ measurements and estimates of the 160- and 180-dB distances collected by the *Langseth* hydrophone streamer were similarly 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with in situ received levels[2] have confirmed that the L-DEO model generated conservative EZs, resulting in significantly larger EZs than necessary.

In July 2016, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a). The new guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sources, onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL_{cum} and SPL_{flat}, respectively. For impulsive sounds, such as airgun pulses, the new guidance incorporates marine mammal auditory weighting functions (Fig. 7) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances.

The SEL_{cum} and Peak SPL for the *Langseth* arrays are derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance (right) below the array (e.g., 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy et al. 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source

[2] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone et al. 2017).

TABLE 1. Level B. Predicted distances to which sound levels ≥160-dB re 1 μPa$_{rms}$ could be received during the proposed surveys in the southwest Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted distances (in m) to the 160-dB received sound level
Single Bolt airgun, 40 in^3	9	>1000 m	388[1]
		100–1000 m	582[2]
		<100 m	938[3]
2 strings, 18 airguns, 3300 in^3	9	>1000 m	3562[1]
		100–1000 m	5343[2]
		<100 m	10,607[3]
4 strings, 36 airguns, 6600 in^3	9	>1000 m	5629[1]
		100–1000 m	8444[2]
		<100 m	22,102[3]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

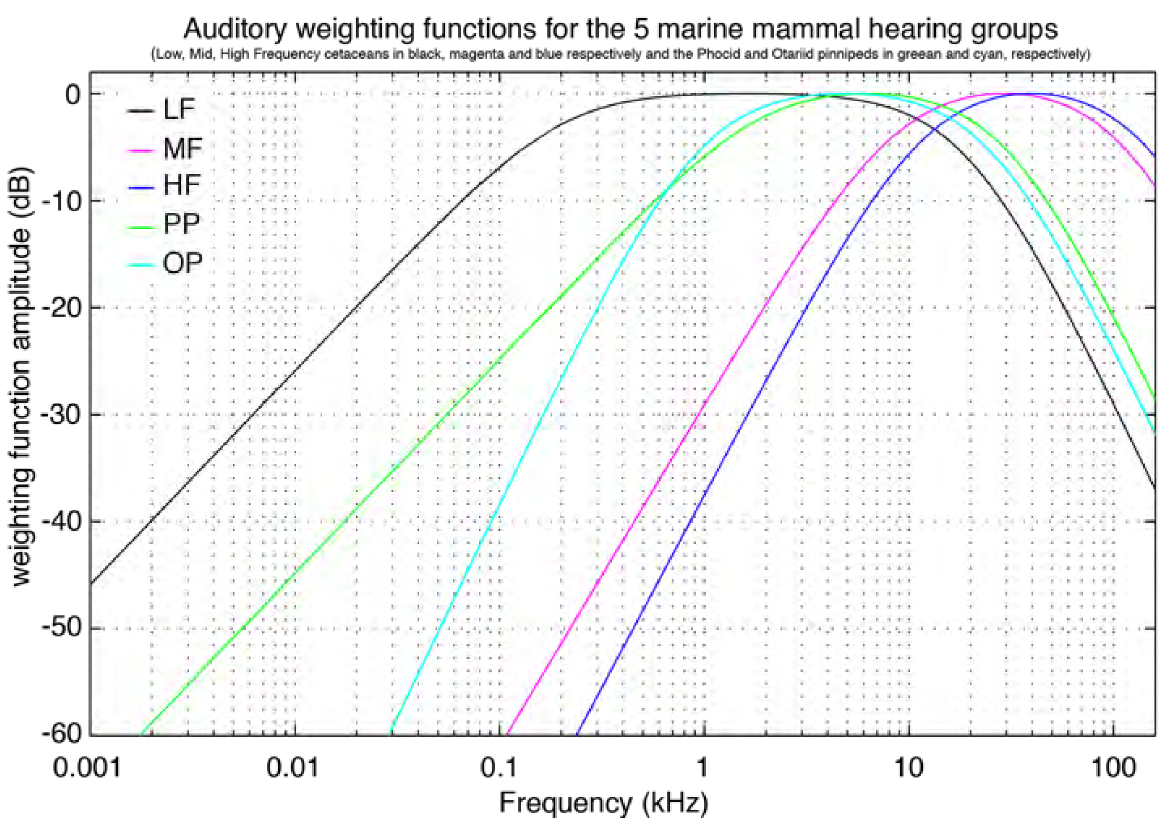

FIGURE 7. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet.

levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the farfield signature is not an appropriate measure of the sound source level for large arrays.

To estimate SEL_{cum} and Peak SPL, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays which we do using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid.

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on override of default values and calculating individual adjustment factors (dB) based on the "modified farfield" and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (source velocity and duty cycle), after Sivle et al. (2014). The methodology (input) for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the 18-airgun and 36-airgun arrays, and the single 40-in^3 mitigation airgun, can be found in the tables that follow. For example, the method of calculating new thresholds for the LF cetaceans for the 36-airgun array is done by estimating a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. The model is run first for a single shot without applying any weighting function; the maximum 183 dB SEL_{cum} isopleth was located at 398.7906 m from the source. Then, the model is run for a single shot with the LF cetacean weighting function applied to the full spectrum; the maximum 183 dB SEL_{cum} isopleth was located at 77.3 m from the source. The difference between 307.1 m and 77.3 m gives an adjustment factor of -11.98 dB assuming a propagation of $20log_{10}$(Radial distance) (See Table 2).

However, for MF and HF cetaceans, and OW and PW pinnipeds, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, and OW and PW pinnipeds, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

For the 36-airgun array, the results for single shot SEL source level modeling are shown in Table 2. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 36-airgun array to be used during the South Island and North Island 2-D surveys are shown in Tables 3 and 4, respectively. Figure 8 shows the impact of weighting functions by hearing group. Figures 9–11 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure 12 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

TABLE 2. Results for single SEL source level modeling for the 36-airgun array to be used during the 2-D surveys with and without applying weighting functions to the five hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Radial Distance (m) (no weighting function)	307.1047	241.9511	7789	241.9511	25.3278
Modified Farfield SEL	232.7457	232.6746	232.8296	232.6746	231.0719
Radial Distance (m) (with weighting function)	77.331	N.A	N.A	N.A	N.A
Adjustment (dB)	-11.98	N.A	N.A	N.A	N.A

* Propagation of 20 log R. N.A. means not applicable or not available.

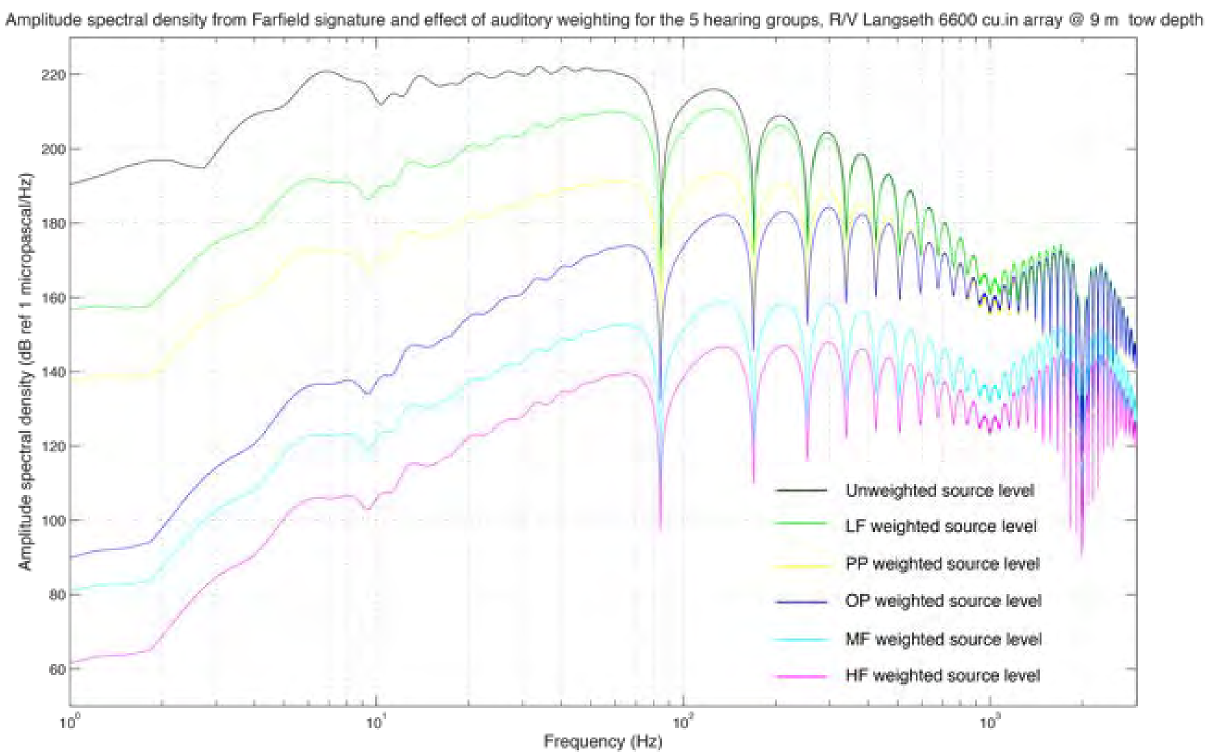

FIGURE 8. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE 3. Results for single shot SEL source level modeling for the 36-airgun array to be used during the South Island 2-D survey with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(red)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Marcus G. Langseth*: Gurnis - New Zealand South Island 2-D Survey
PROJECT/SOURCE INFORMATION (Please include any assumptions)	4 strings, 6600 cu.in, 36 element airgun source array @ a 9 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD[†] TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.315	4.5 kt Tow Speed
1/Repetition rate^ (seconds)	21.5982	50 m Shot Point Interval

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	232.75	232.67	232.83	232.67	231.07
Source Factor	8.72132E+21	8.56214E+21	8.88347E+21	8.56214E+21	5.92356E+21

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SEL_{cum} & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	376.0	0	0.9	9.9	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-11.98	-56.84	-66.22	-25.70	-32.77	OVERIDE Using LDEO Modeling

[†]For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 8).

TABLE 4. Results for single shot SEL source level modeling for the 36-airgun array to be used during the North Island 2-D survey with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(teal)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Marcus G. Langseth*: SHIRE - New Zealand North Island 2-D Survey
PROJECT/SOURCE INFORMATION	4 strings, 6600 cu.in, 36 element airgun source array @ a 9 m tow depth
Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)¥	NA	Override WFA: Using LDEO modeling

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.212	4.3 kt Tow Speed for 12.5-km Streamer
1/Repetition rate^ (seconds)	16.953	37.5 m Shot Interval

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	232.75	232.67	232.83	232.67	231.07
Source Factor	1.1111E+22	1.09082E+22	1.13176E+22	1.09082E+22	7.54664E+21

RESULTANT ISOPLETHS* — *Impulsive sounds have dual metric thresholds (SEL_{cum} & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	501.3	0	1.2	13.2	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-11.98	-56.84	-66.22	-25.70	-32.77	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 8).

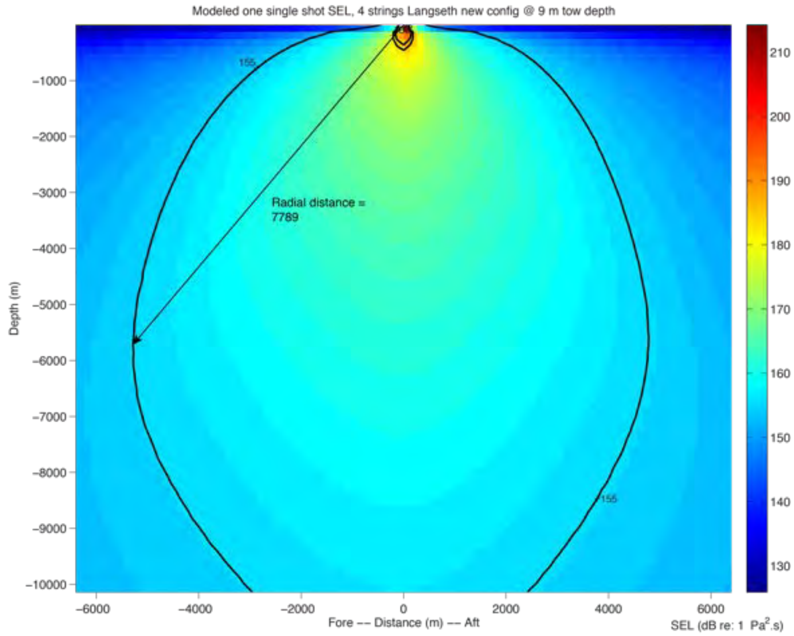

FIGURE 9. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (7789 m). Radial distance allows us to determine the modified farfield SEL using a propagation of $20\log_{10}$(radial distance).

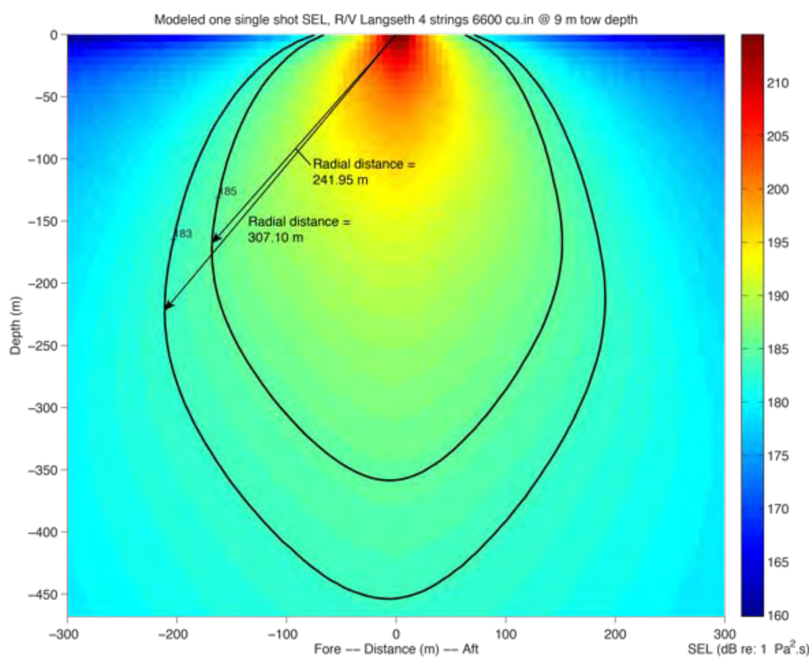

FIGURE 10. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (307.10 and 241.95 m, respectively).

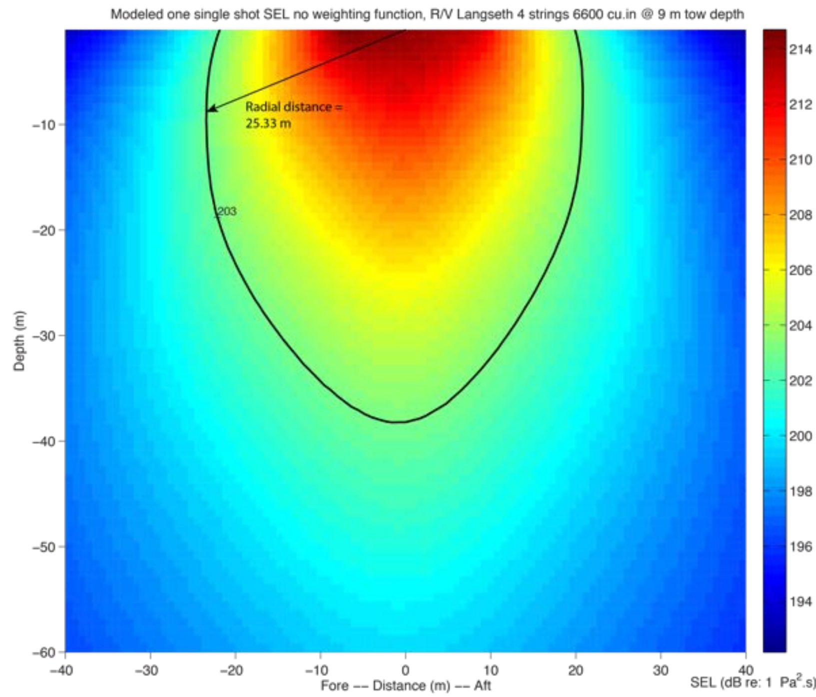

FIGURE 11. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB SEL isopleth (25.33 m).

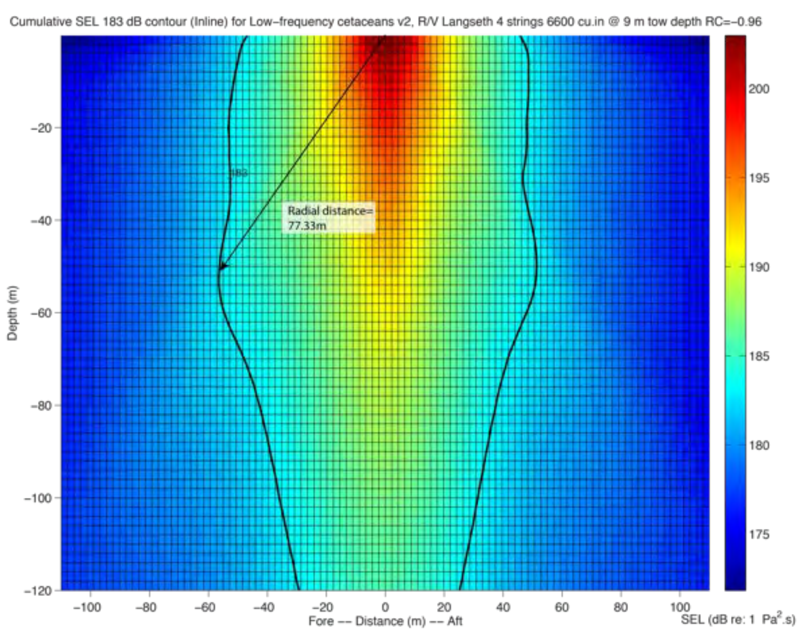

FIGURE 12. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 9-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. 10 and this figure (77.33 m) allows us to estimate the adjustment in dB.

The thresholds for Peak SPL_{flat} for the 36-airgun array, as well as the distances to the PTS thresholds, are shown in Table 5. Figures 13–15 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

For the 18-airgun array to be used during the North Island 3-D survey, the results for single shot SEL source level modeling are shown in Table 6. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 18-airgun array are shown in Table 7. Figure 16 shows the impact of weighting functions by hearing group. Figures 17–19 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure 20 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

The thresholds for Peak SPL_{flat} for the 18-airgun array, as well as the distances to the PTS thresholds, are shown in Table 8. Figures 21–23 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

For the single 40 in^3 mitigation airgun, the results for single shot SEL source level modeling are shown in Table 9. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 40 in^3 airgun are shown in Tables 10–12 for each of the three surveys; although the same mitigation airgun is proposed for use for all three surveys, the calculations differ due to the differences in duty cycles and survey speeds of the surveys. Figure 24 shows the impact of weighting functions by hearing group. Figures 25–26 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups.

Figure 27 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans. The thresholds for Peak SPL_{flat} for the 40 in^3 airgun, as well as the distances to the PTS thresholds, are shown in Table 13. Figures 28–29 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

A summary of the Level A threshold distances for each survey are shown in Table 14.

The new guidance drew from recommendations for new science-based noise exposure criteria described in Southall et al. (2007); however, it did not alter the current threshold, 160 dB re $1\mu Pa_{rms}$, for Level B harassment (behavior). At the time of preparation of this document, how the guidance would be implemented operationally remains somewhat uncertain. In addition, this document 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. (2013a), Wright (2014), and Wright and Cosentino (2015).

Table 15 shows the distances at which the 175- and 195-dB re $1\mu Pa_{rms}$ sound levels are expected to be received for the 18-airgun and 36-airgun arrays, and a single airgun, based on L-DEO modeling; the 195-dB distance would be used as the EZ for sea turtles, as required by NMFS, and the 175-dB level is used by NMFS to determine behavioral disturbance for turtles.

Enforcement of mitigation zones via power and shut downs would be implemented as described in § XI.

TABLE 5. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 36-airgun array during the proposed 2-D seismic surveys in the southwestern Pacific Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Peak Threshold	**219**	**230**	**202**	**218**	**232**
PTS Peak Isopleth (radius) to threshold (m)	38.78	13.75	229.15	42.17	10.87
Modified Farfield Peak	250.77	252.76	249.44	250.50	252.72

N.A. means not applicable or not available.

TABLE 6. Results for single shot SEL source level modeling for the 18-airgun array to be used during the North Island 3-D survey with and without applying weighting function to the various hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	144.8528	113.9293	3869.7	113.9293	15.6619
Modified Farfield SEL	226.2185	226.1327	226.7535	226.1327	226.8969
Distance (m) (with weighting function)	29.536	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-13.81	N.A.	N.A.	N.A.	N.A.

N.A. means not applicable or not available.

TABLE 7. Results for single shot SEL source level modeling for the 18-airgun array to be used during the 3-D North Island survey with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(red)	NMFS Provided Information (Acoustic Guidance)
(cyan)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Marcus G. Langseth*: Bangs - New Zealand 3-D MCS North Island Survey
PROJECT/SOURCE INFORMATION (Please include any assumptions)	2 strings 3300 cu.in. 18 airgun array @ a 9 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) — NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.315	4.5 kt Tow Speed
1/Repetition rate^ (seconds)	16.199	37.5 m Shot Interval

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	226.2185	226.1327	226.7535	226.1327	226.8969
Source Factor	2.58441E+21	2.53386E+21	2.92322E+21	2.53386E+21	3.02136E+21

RESULTANT ISOPLETHS* — *Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	73.1	0	0.3	2.8	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-13.81	-56.94	-66.30	-25.89	-32.85	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 16).

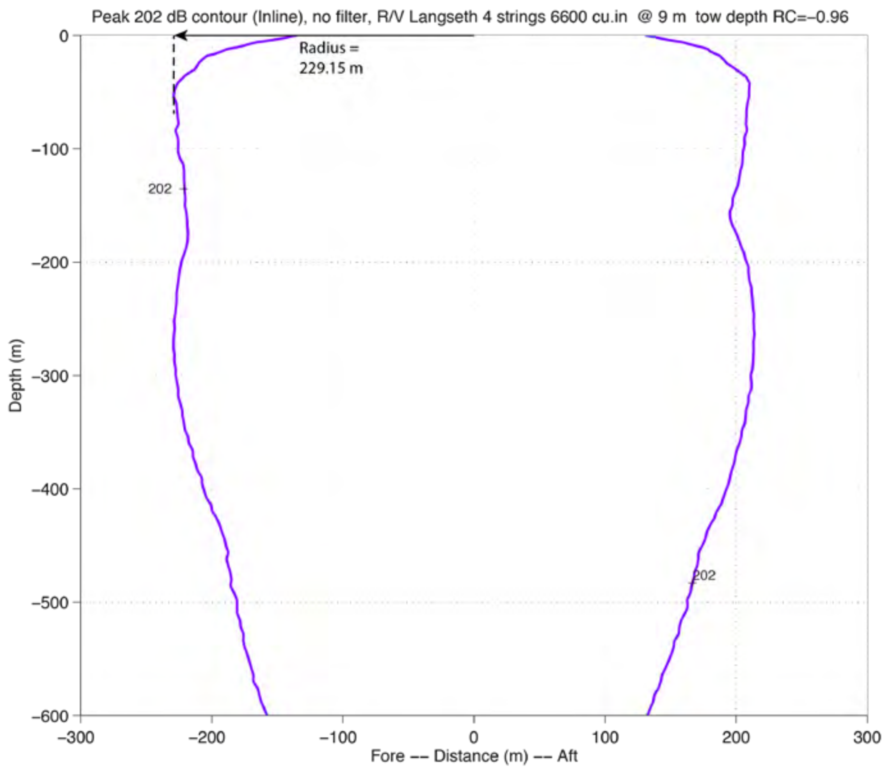

FIGURE 13. Modeled deep-water received Peak SPL from the 36-airgun array at a 9-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

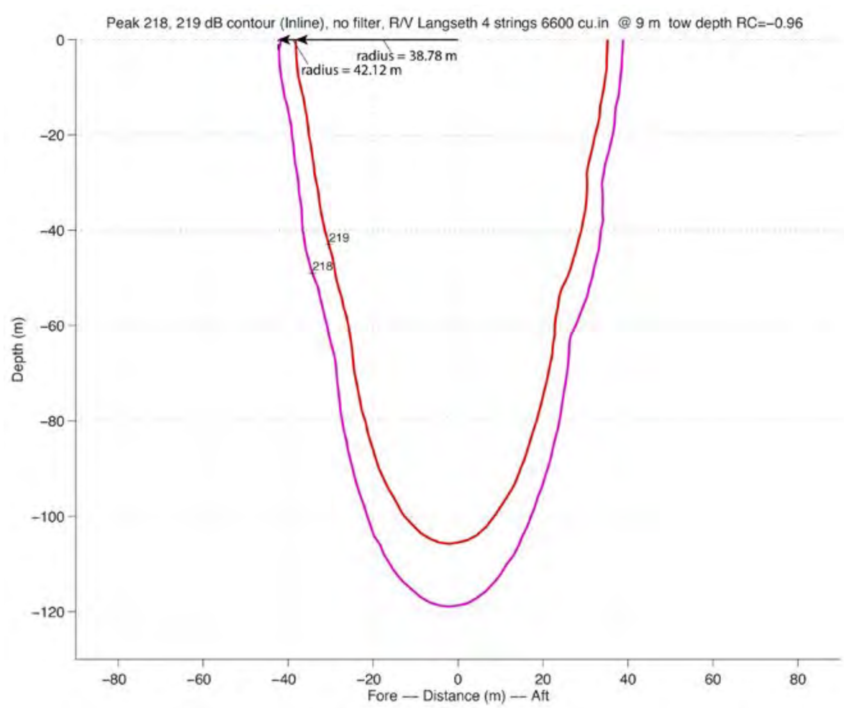

FIGURE 14. Modeled deep-water received Peak SPL from the 36-airgun array at a 9-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

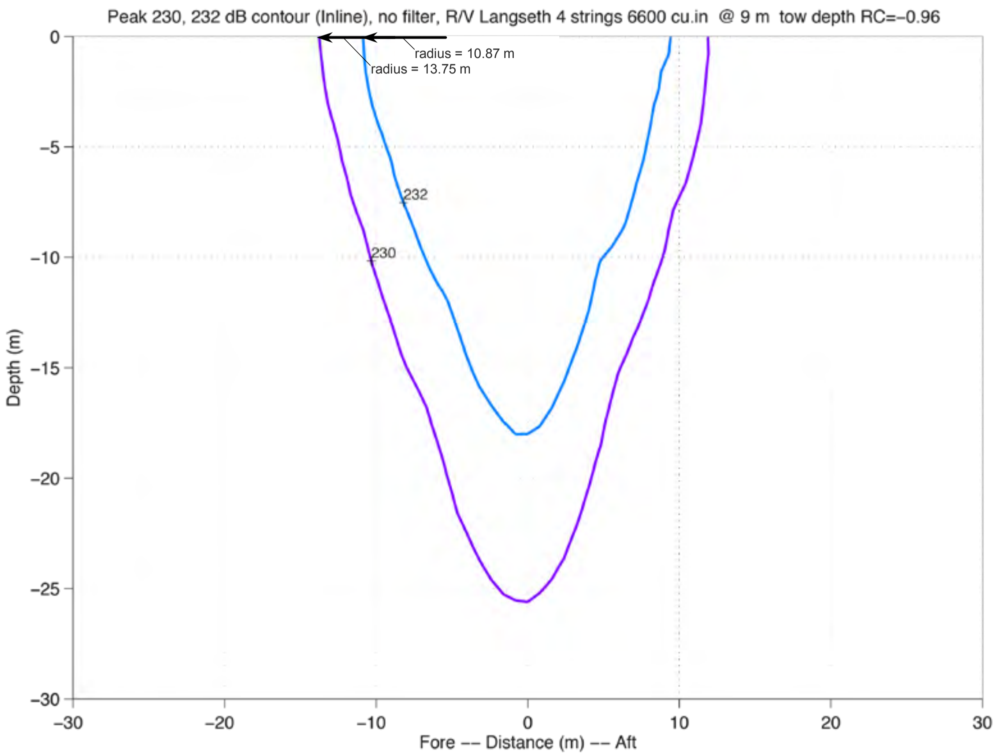

FIGURE 15. Modeled deep-water received Peak SPL from the 36-airgun array at a 9-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

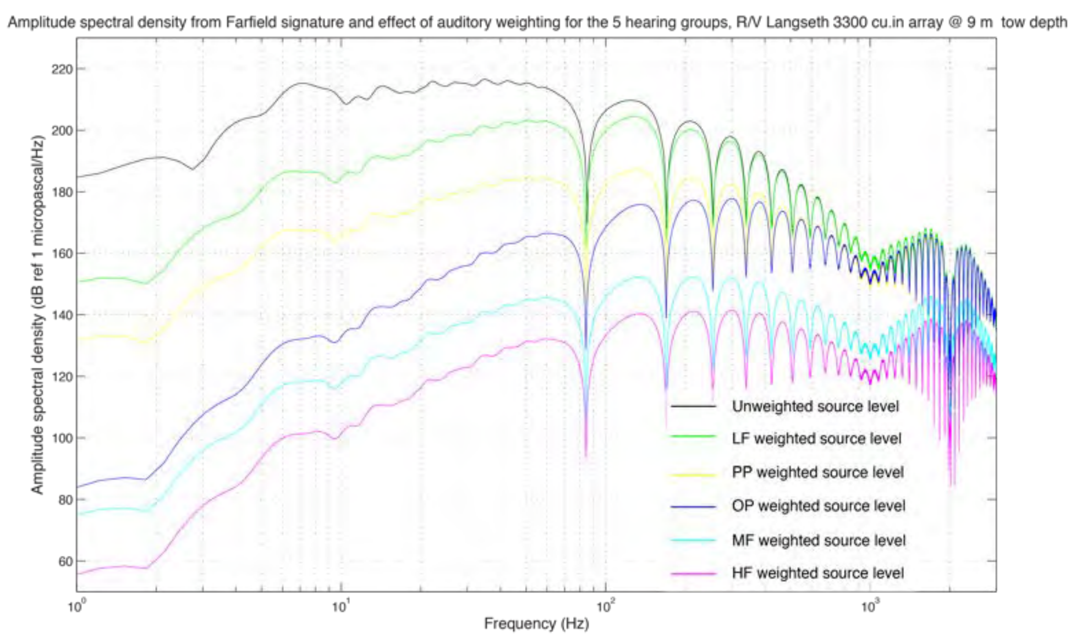

FIGURE 16. Modeled amplitude spectral density of the 18-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

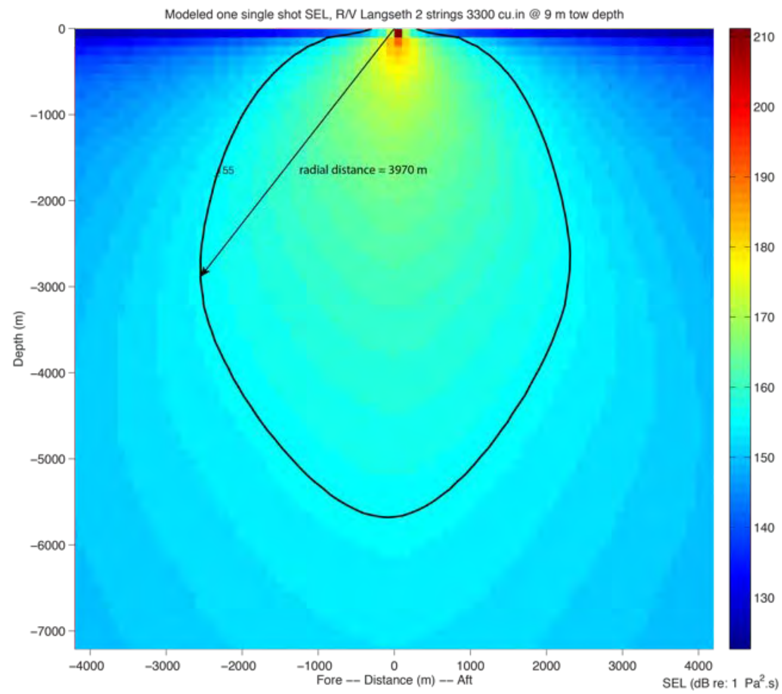

FIGURE 17. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (3970 m).

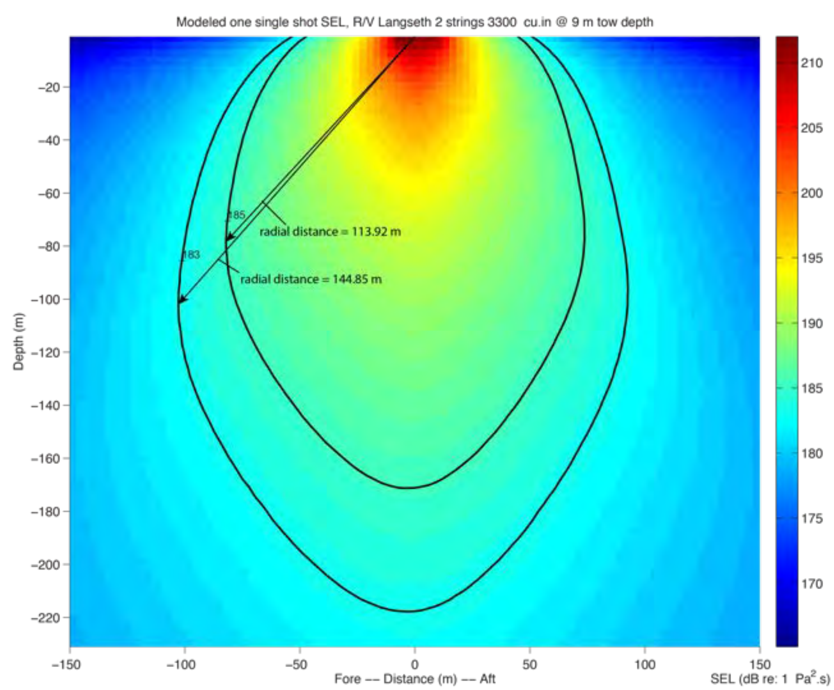

FIGURE 18. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the distance from the geometrical center of the source array to the 183–185-dB SEL isopleths

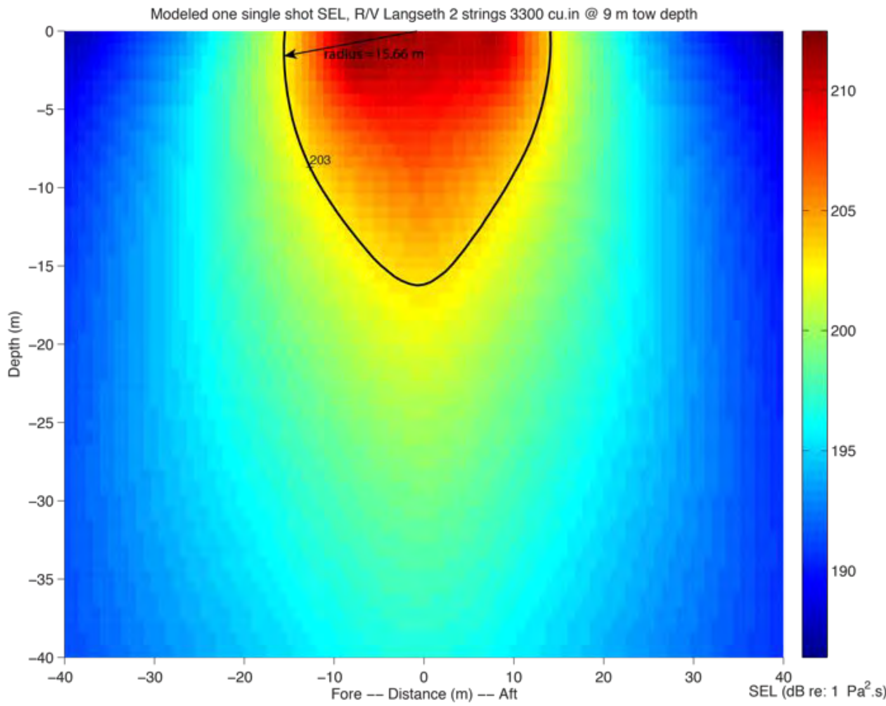

FIGURE 19. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the distance from the geometrical center of the source array to the 203-dB SEL isopleth.

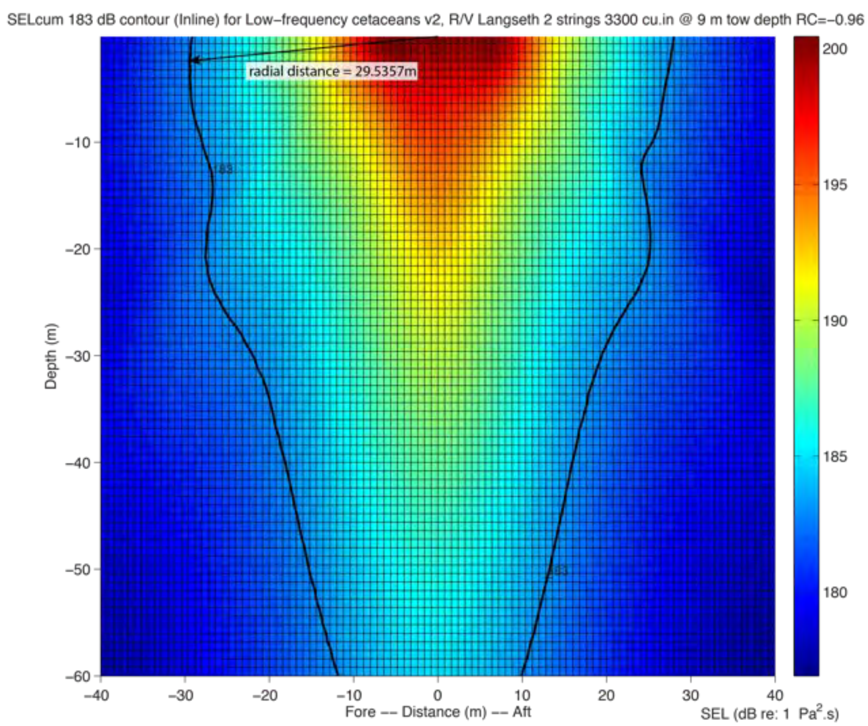

FIGURE 20. Modeled received sound exposure levels (SELs) from the 18-airgun array at a 9-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following to the NMFS Technical Guidance. The plot provides the radius to the 183-dB SEL_{cum} isopleth for one shot.

TABLE 8. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 18-airgun array during the proposed North Island 3-D seismic survey in the southwestern Pacific Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
Peak Threshold	**219**	**230**	**202**	**218**	**232**
PTS Peak Isopleth (radius) to threshold (m)	23.268	11.198	118.955	25.217	9.919
Modified Farfield Peak	246.335	250.983	243.641	246.034	251.929

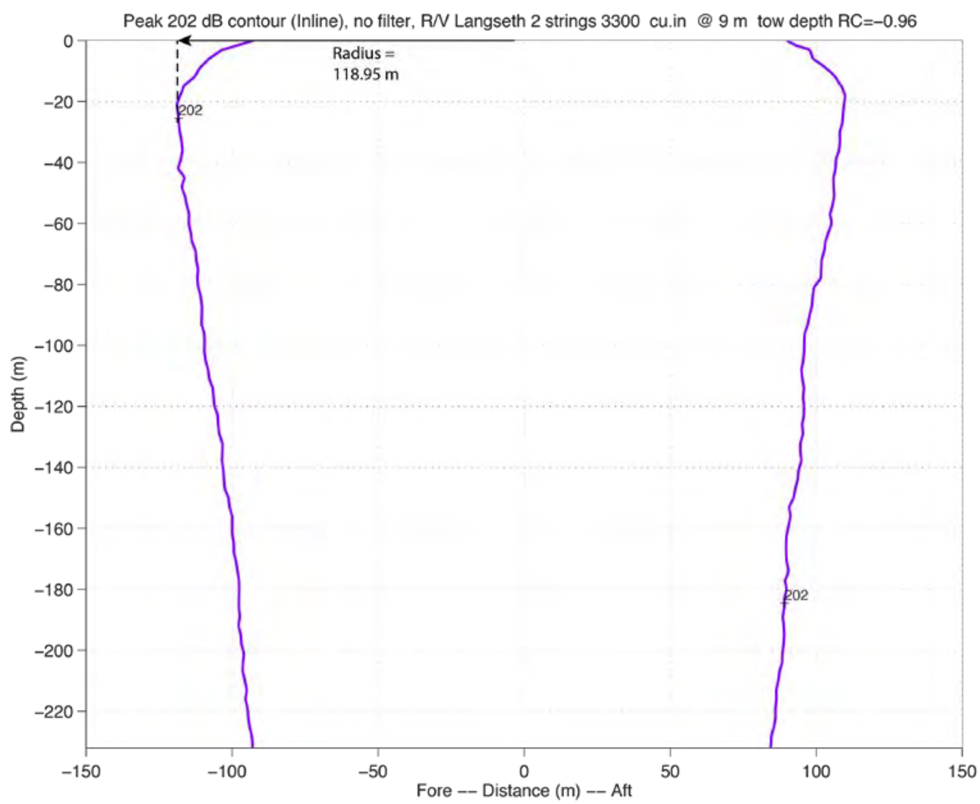

FIGURE 21. Modeled deep-water received Peak SPL from the 18-airgun array at a 9-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

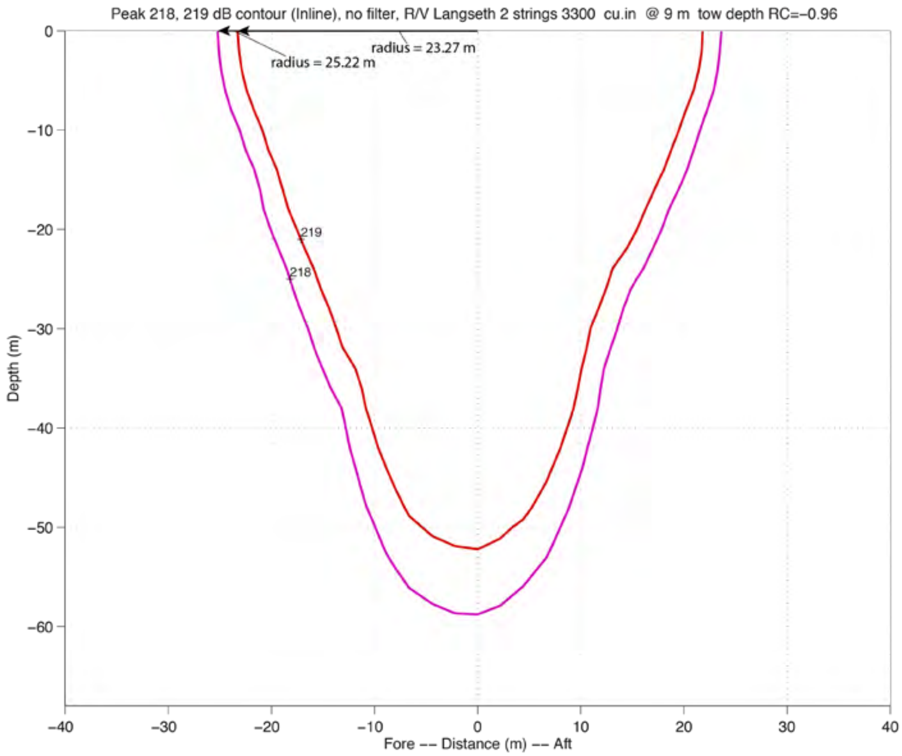

FIGURE 22. Modeled deep-water received Peak SPL from the 18-airgun array at a 9-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

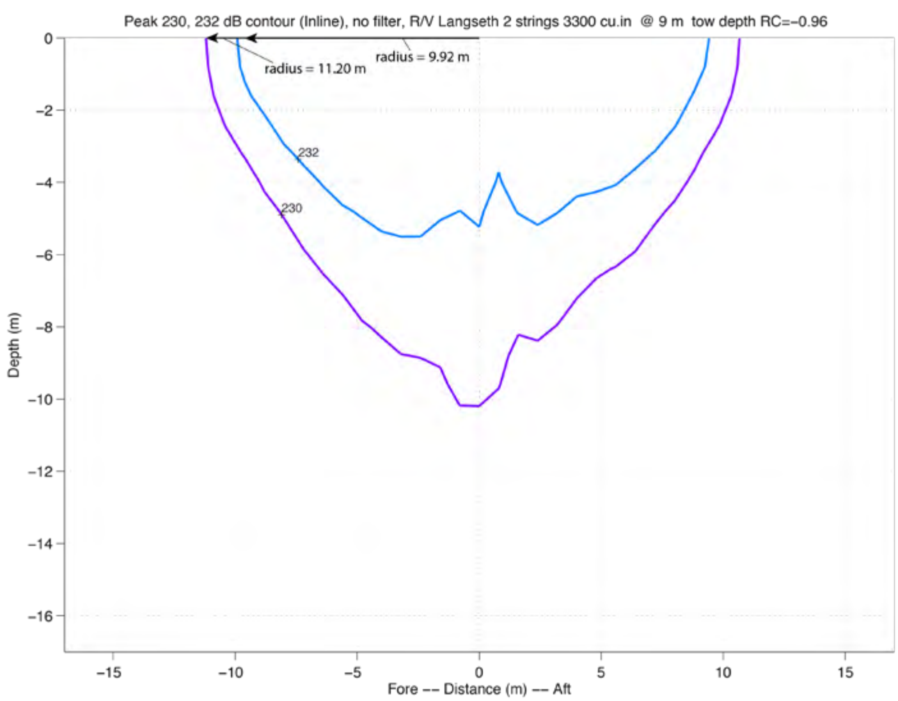

FIGURE 23. Modeled deep-water received Peak SPL from the 18-airgun array at a 9-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

TABLE 9. Results for single shot SEL source level modeling for the 40 in^3 airgun with and without applying weighting function to the various hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**
Distance(m) (no weighting function)	9.253	7.374	254.579	7.374	0.956
Modified Farfield SEL	202.3257	202.3541	203.1165	202.3541	202.6092
Distance (m) (with weighting function)	2.292	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-12.12	N.A.	N.A.	N.A.	N.A.

N.A. means not applicable or not available.

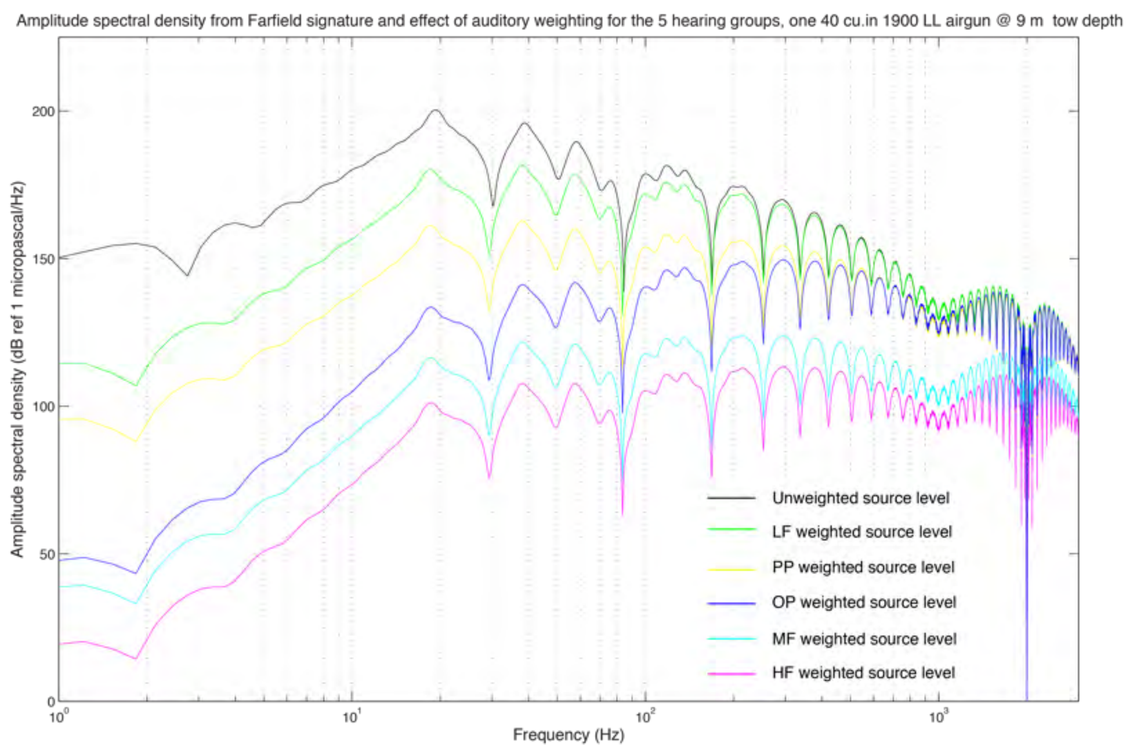

FIGURE 24. Modeled amplitude spectral density of the 40-in^3 airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE 10. Results for single shot SEL source level modeling for the single 40 in^3 mitigation airgun to be used during the South Island 2-D survey, with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(red)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Langseth* mitigation airgun - South Island 2-D Survey
PROJECT/SOURCE INFORMATION (Please include any assumptions)	one 40 cu.in. 1900LL airgun @ a 9 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) — NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD[†] TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.315	
1/Repetition rate^ (seconds)	21.598	50m Shot Point Interval

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	202.3257	202.3541	203.1165	202.3541	202.6092
Source Factor	7.90964E+18	7.96153E+18	9.48935E+18	7.96153E+18	8.44319E+18

RESULTANT ISOPLETHS* — *Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	0.3	0	0	0	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.12	-59.95	-69.09	-29.31	-35.78	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 24).

TABLE 11. Results for single shot SEL source level modeling for the single 40 in^3 mitigation airgun to be used during the North Island 2-D survey, with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(red)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Langseth* mitigation gun - North Island 2-D Survey
PROJECT/SOURCE INFORMATION (Please include any assumptions)	one 40 cu.in. 1900LL airgun @ a 9 m tow depth
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)$^¥$	NA	Override WFA: Using LDEO modeling

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.212	
1/Repetition rate^ (seconds)	16.953	37.5m Shot Point Interval

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	202.3257	202.3541	203.1165	202.3541	202.6092
Source Factor	1.00768E+19	1.01429E+19	1.20894E+19	1.01429E+19	1.07566E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	0.4	0	0	0	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.12	-59.95	-69.09	-29.31	-35.78	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 24).

TABLE 12. Results for single shot SEL source level modeling for the single 40 in^3 mitigation airgun to be used during the North Island 3-D survey, with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(red)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V *Langseth* mitigation gun - North Island 3-D Survey
PROJECT/SOURCE INFORMATION	one 40 cu.in. 1900LL airgun @ a 9 m tow depth
Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.315		
1/Repetition rate^ (seconds)	16.199	37.5 m Shot Interval	16.1987041

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	202.3257	202.3541	203.1165	202.3541	202.6092
Source Factor	1.05459E+19	1.0615E+19	1.26521E+19	1.0615E+19	1.12572E+19

RESULTANT ISOPLETHS* *Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	0.4	0	0	0	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.12	-59.95	-69.09	-29.31	-35.78	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure 24).

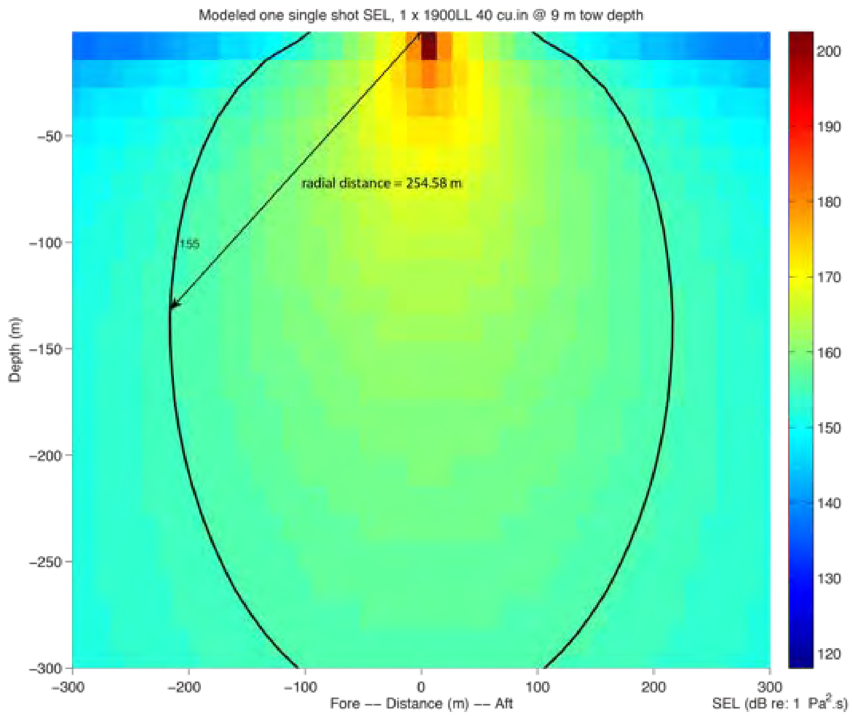

FIGURE 25. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 9 m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (254.58 m).

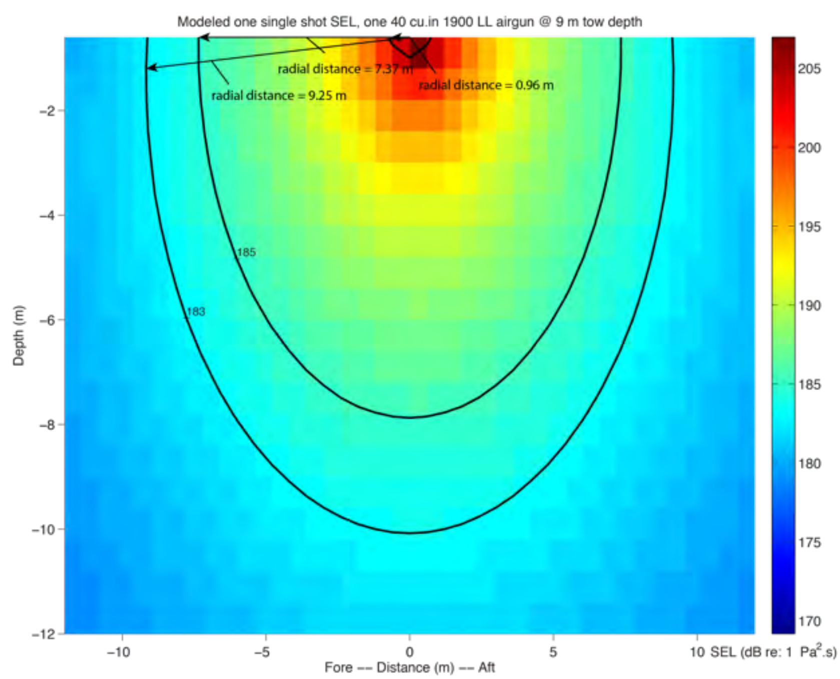

FIGURE 26. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 9 m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

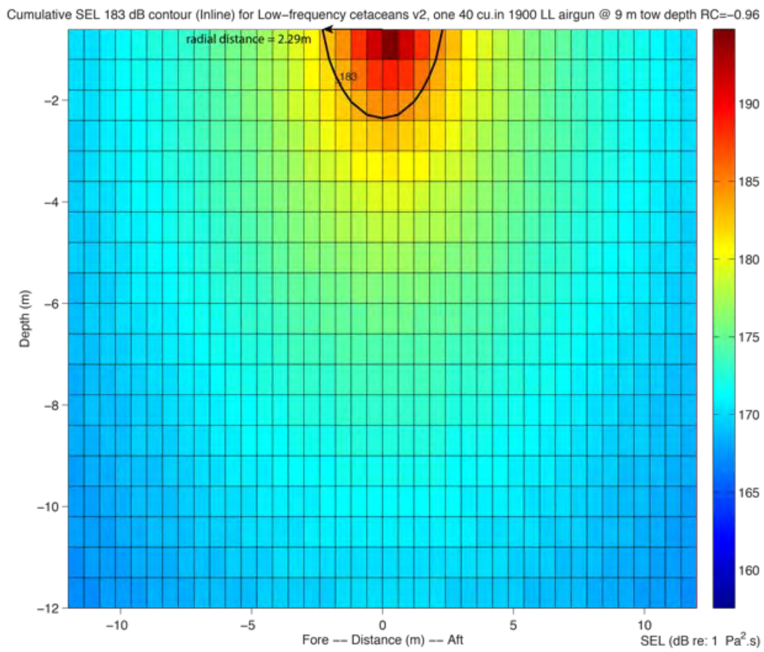

FIGURE 27. Modeled received sound exposure levels (SELs) from one 40-in^3 mitigation at a 9-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. 26 (254.58 m) and this figure (2.29 m) allows us to estimate the adjustment in dB.

TABLE 13. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 40-in^3 airgun during the proposed seismic surveys in the southwestern Pacific Ocean.

Hearing Group	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
Peak Threshold	**219**	**230**	**202**	**218**	**232**
PTS Peak Isopleth (radius) to threshold (m)	1.782	0.573	12.59	2.015	0.54
Modified Farfield Peak	224.02	225.16	224.00	224.09	226.64

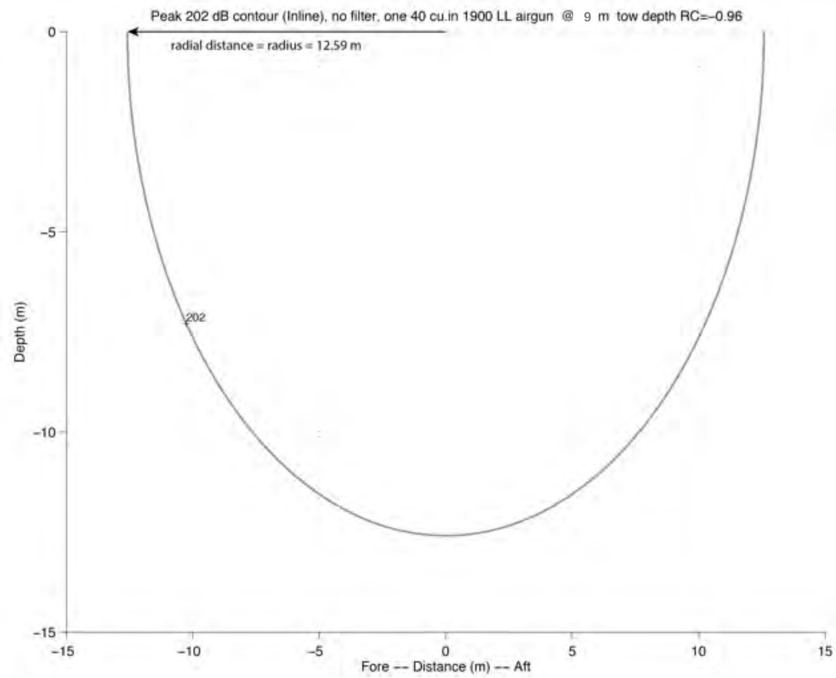

FIGURE 28. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 9-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth (12.59 m).

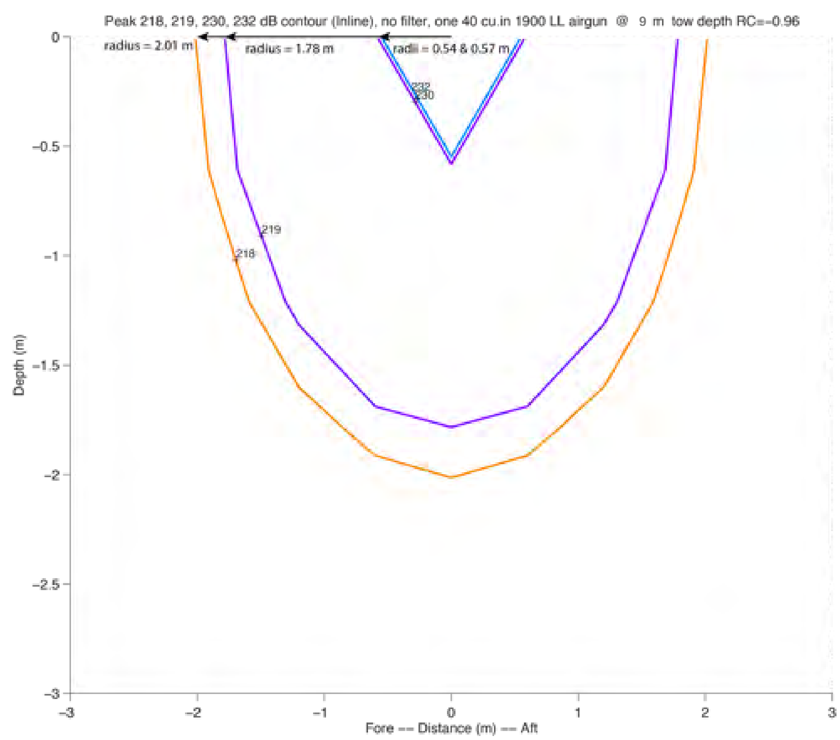

FIGURE 29. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 9-m tow depth. The plot provides the radial distances from the source geometrical center to the 218, 219, 230, and 232-dB Peak isopleths.

TABLE 14. Level A threshold distances for the different marine mammal hearing groups. As required by NMFS (2016a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances.

Seismic Survey / Airgun Array	**Level A Threshold Distances (m) for Various Hearing Groups**				
	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
South Island 2-D / 36 airguns	376.0[1]	13.8[2]	229.2[2]	42.1[2]	10.9[2]
North Island 2-D / 36 airguns	501.3[1]	13.8[2]	229.2[2]	42.1[2]	10.9[2]
North Island 3-D / 18 airguns	73.1[1]	11.2[2]	119.0[2]	25.2[2]	9.9[2]

[1] Distance based on SEL_{cum} criterion.
[2] Distance based on Peak SPL_{flat} criterion.

TABLE 15. Sea turtle thresholds recommended by NMFS. Predicted distances to which sound levels ≥195- and 175-dB re 1 μPa_{rms} could be received during the proposed surveys in the southwest Pacific Ocean.

Source and Volume	**Tow Depth (m)**	**Water Depth (m)**	**Predicted distances (in m) to various received sound levels**	
			195 dB	**175 dB**
Single Bolt airgun, 40 in^3	9	>1000 m	7[1]	66[1]
		100–1000 m	11[2]	99[2]
		<100 m	12[3]	142[3]
2 strings, 18 airguns, 3300 in^3	9	>1000 m	79[1]	775[1]
		100–1000 m	119[2]	1163[2]
		<100 m	150[3]	1710[3]
4 strings, 36 airguns, 6600 in^3	9	>1000 m	155[1]	1618[1]
		100–1000 m	233[2]	2427[2]
		<100 m	296[3]	3580[3]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

OBS Description and Deployment

During the proposed South Island 2-D survey, the *Langseth* would deploy ~43 OBSs provided by UT. All seismic refraction data would be collected before MCS data. The OBSs would first be deployed along the OBS line south of Snares Islands, seismic data would be acquired, and the OBSs would be recovered. The *Langseth* would then deploy OBSs along the OBS line north of Snares Island, seismic data would be acquired, and OBSs would be recovered. The OBSs have a height of ~1 m and a maximum diameter of ~1 m. The anchors are 120 × 120 × 33 cm in dimension and weigh 50-kg. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface.

Description of Operations

The procedures to be used for the proposed surveys would be similar to those used during previous seismic surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, the *Langseth*, which is owned by NSF and operated on its behalf by Columbia University's L-DEO. The *Langseth* would deploy an array of 18 or 36 airguns as an energy source with a total volume of ~3300 or 6600 in^3, respectively. The receiving system would consist of either four 6-km long hydrophone streamers (North Island 3-D survey) or a single hydrophone streamer up to 12.5 km in length (~12.5-km long streamer for North Island 2-D survey; ~8-km long streamer for South Island 2-D survey) and OBSs (2-D surveys). As the airgun arrays are towed along the survey lines, the hydrophone streamer(s) would transfer the data to the on-board processing system, and the OBSs would receive and store the returning acoustic signals internally for later analysis.

A total of ~13,299 km of transect lines would be surveyed in the southwest Pacific Ocean off New Zealand: ~3025 km during the North Island 3-D survey, ~5398 km during the North Island 2-D survey, and ~4876 km during the South Island 2-D survey. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the calculations (see § VII), 25% has been added in the form of operational days, which is equivalent to adding 25% to the proposed line km to be surveyed. In addition to the operations of the airgun array, the ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. A Teledyne RDI 75 kHz Ocean Surveyor ADCP would be used to measure water current velocities. These sources are described in § 2.2.3.1 of the PEIS.

II. Dates, Duration, and Region of Activity

The date(s) and duration of such activity and the specific geographical region where it will occur.

The proposed North Island 2-D survey would occur within ~37–43°S between 180°E and the east coast of North Island, and the proposed North Island 3-D survey would occur within ~38–39.5°S, ~178–179.5°E. The proposed South Island 2-D survey would occur within ~163–168°E between 50°S and the south coast of South Island. The seismic surveys would be conducted within the EEZ of New Zealand; only a small proportion would take place in Territorial Waters. Representative survey tracklines are shown in Figures 1 and 2; however, some deviation in actual track lines could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment.

The North Island 2-D survey would consist of ~35 days of seismic operations plus ~2 days of transit and towed equipment deployment/retrieval. The *Langseth* would depart Auckland on ~26 October and arrive in Wellington on 1 December 2017. The North Island 3-D survey is proposed for ~5 January–8 February 2018 and would consist of ~33 days of seismic operations plus ~2 days of transit and towed equipment deployment/retrieval. The *Langseth* would leave and return to port in Napier. The South Island 2-D survey is proposed for ~15 February–15 March 2018 and would consist of ~22 days of seismic operations, ~3 days of transit, and ~7 days of OBS deployment/retrieval. The *Langseth* would leave and return to port in Dunedin.

Seasonality of the proposed survey operations does not affect the ensuing analysis (including take estimates), because the best available species densities for any time of the year have been used. It is likely that fewer baleen whales would be encountered in the region during austral summer, as they are typically found at lower latitudes at that time of the year.

III. Species and Numbers of Marine Mammals in Area

The species and numbers of marine mammals likely to be found within the activity area

New Zealand is considered a hotspot for marine mammal species richness (Kaschner et al. 2011). Thirty-nine marine mammal species (or subspecies), including 26 odontocetes, nine mysticetes, and four pinnipeds could occur in the proposed seismic survey areas (Table 16). To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below.

IV. Status, Distribution and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

Sections III and IV are integrated here to minimize repetition.

Five of the 39 species/sub-species that could occur in the proposed survey areas off New Zealand are listed under the U.S. Endangered Species Act (ESA) as ***endangered***: the sperm, blue, fin, sei, and southern right whales. In addition, the two subspecies of Hector's dolphin, Maui's dolphin and South Island Hector's dolphin, are proposed for listing as ***endangered*** and ***threatened***, respectively.

Based on the New Zealand Threat Classification System, five of the 35 species are threatened and classified as *nationally critical*, including Bryde's whale, killer whale, Maui's dolphin, southern elephant seal, and New Zealand sea lion (Baker et al. 2016a). Two species ranked as *nationally endangered* (Hector's dolphin and the bottlenose dolphin), and the *nationally vulnerable* southern right whale could also occur in the proposed survey areas (Baker et al. 2016a).

Baker et al. (2016a) classified 19 species as *vagrant* under the New Zealand Threat Classification System, including: ginkgo-toothed whale (*Mesoplodon ginkgodens*), pygmy beaked whale (*M. peruvianus*), dwarf sperm whale (*Kogia sima*), Types B, C, D killer whale (*Orcinus orca*), pygmy killer whale (*Feresa attenuata*), 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*). Except for Risso's dolphin and the leopard seal, for which there have been several sightings and

TABLE 16. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur near the proposed seismic survey areas off New Zealand, southwest Pacific Ocean.

Species	Habitat	Occurrence October-March	Population Size[1]	U.S. ESA[2]	IUCN[3]	CITES[4]	NZ[5]
Mysticetes							
Southern right whale	Coastal, shelf, occ. offshore	Common/ Uncommon[17]	12,000[6]	EN	LC	I	NE
Pygmy right whale	Coastal, pelagic	Rare	N.A.	NL	DD	I	DD
Humpback whale	Coastal, pelagic	Common	42,000[6]	NL	LC	I	M
Bryde's whale	Coastal, pelagic	Common/ Rare[11]	48,109[7]	NL	DD	I	NC
Common minke whale	Coastal, shelf	Uncommon	750,000[8,9]	NL	LC	I	NT
Antarctic minke whale	Coastal, pelagic	Uncommon	750,000[8,9]	NL	DD	I	NT
Sei whale	Mostly pelagic	Uncommon	10,000[8]	EN	EN	I	M
Fin whale	Pelagic	Uncommon	15,000[8]	EN	EN	I	M
Blue whale	Coastal, shelf, pelagic	Uncommon	2300 true[6], 1500 pygmy[8]	EN	EN	I	M
Odontocetes							
Sperm whale	Slope, oceanic, canyons	Common	30,000[8]	EN	VU	I	NT
Pygmy sperm whale	Outer shelf, pelagic	Uncommon	N.A.	NL	DD	II	NT
Cuvier's beaked whale	Mostly over slope	Uncommon	600,000[8,10]	NL	LC	II	DD
Arnoux's beaked whale	Pelagic	Uncommon	600,000[8,10]	NL	DD	I	M
Southern bottlenose whale	Pelagic	Rare	600,000[8,10]	NL	LC	I	DD
Shepherd's beaked whale	Pelagic	Rare	600,000[8,10]	NL	DD	II	DD
Hector's beaked whale	Pelagic	Rare	600,000[8,10]	NL	DD	II	DD
True's beaked whale	Pelagic	Very rare	N.A.	NL	DD	II	DD
Gray's beaked whale	Pelagic	Uncommon	600,000[8,10]	NL	DD	II	NT
Andrew's beaked whale	Pelagic	Rare	600,000[8,10]	NL	DD	II	DD
Strap-toothed beaked whale	Pelagic	Uncommon	600,000[8,10]	NL	DD	II	DD
Blainville's beaked whale	Slope	Very rare	600,000[8,10]	NL	DD	II	DD
Spade-toothed beaked whale	Presumed pelagic	Very rare	600,000[8,10]	NL	DD	II	DD
Common bottlenose dolphin	Coastal, shelf, pelagic	Common	N.A.	NL	LC	II	NE
Short-beaked common dolphin	Mostly pelagic	Abundant	N.A.	NL	LC	II	NT
Dusky dolphin	Shelf, slope	Common	12,000-20,000 NZ[12]	NL	DD	II	NT
Hourglass dolphin	Pelagic	Rare	150,000[8]	NL	LC	II	DD
Southern right whale dolphin	Pelagic	Uncommon	N.A.	NL	DD	II	NT
Risso's dolphin	Outer shelf, slope, pelagic	Rare	N.A.	NL	LC	II	V
Hector's dolphin	Coastal	Rare/ Uncommon[19]	14,849[13]	NL[14]	EN	II	NE
Maui's dolphin	Coastal	Rare	55-63[15]	NL[14]	CR	II	NC
False killer whale	Pelagic, occ. shelf	Uncommon	N.A.	NL	DD	II	NT
Killer whale	Coastal, occ. pelagic	Common	80,000[8]	NL	DD	II	NC[16]
Long-finned pilot whale	Mostly pelagic	Common	200,000[8]	NL	DD	II	NT
Short-finned pilot whale	Pelagic	Uncommon	N.A.	NL	DD	II	M
Spectacled porpoise	Pelagic	Rare	N.A.	NL	DD	II	DD

Species	Habitat	Occurrence October-March	Population Size[1]	U.S. ESA[2]	IUCN[3]	CITES[4]	NZ[5]
Pinnipeds							
New Zealand fur seal	Coastal, shelf, pelagic	Common	200,000 NZ[12]	NL	LC	II	NT
New Zealand sea lion	Coastal, shelf, pelagic	Uncommon	9880[18]	NL	EN	II	NC
Southern elephant seal	Coastal, shelf, pelagic	Rare	607,000 NZ[12]	NL	LC	II	NC
Leopard seal	Coastal, shelf, pelagic	Rare	222,000[12]	NL	LC	II	V

NZ = New Zealand; N.A. = Not Available; occ. = occasionally
[1] Abundance for the Southern Hemisphere or Antarctic unless otherwise noted
[2] U.S. Endangered Species Act (ESA) (NMFS 2017); EN = Endangered; NL = Not Listed
[3] Codes for classifications from IUCN Red List of Threatened Species (IUCN 2016): CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient
[4] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2017): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
[5] New Zealand Threat Classification System (Baker et al. 2016a); NC = Nationally Critical; NE = Nationally Endangered; NV = Nationally Vulnerable; DD = Data Deficient; NT = Not Threatened; M = Migrant; V = Vagrant
[6] IWC (2016)
[7] IWC (1981)
[8] Boyd (2002)
[9] Dwarf and Antarctic minke whales combined
[10] All Antarctic beaked whales combined
[11] Common in Bay of Plenty; rare elsewhere in proposed survey area
[12] Estimate for New Zealand (NZDOC 2017a)
[13] Estimate for New Zealand (MacKenzie and Clement 2016)
[14] Two subspecies proposed for listing; Maui's dolphin (*Cephalorhynchus hectori maui*) proposed endangered, and South Island Hector's dolphin (*C.h. hectori*) proposed threatened
[15] Population size for New Zealand from Hamner et al. (2014) and Baker et al. (2016b)
[16] Only Type A is considered nationally critical; Types B,C, D are considered vagrant
[17] Common during the spring North Island survey and the summer South Island survey; uncommon during the summer North Island survey
[18] Geschke and Chilvers (2009)
[19] Rare in North Island survey areas; uncommon in most of the offshore South Island survey area

strandings in New Zealand (Clement 2010; Torres 2012; Berkenbusch et al. 2013; NZDOC 2017b), the other *vagrant* species have not been included in Table 16.

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 areas, 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 NZDOC marine mammal sightings and strandings database (NZDOC 2017b).

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. 2014a; Jackson et al. 2016). 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; Torres et al. 2016), as well as mainland New Zealand (Patenaude 2003; Carroll et al. 2014b). 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). Genetic data have shown long-term fidelity to calving grounds (Carroll et al. 2015, 2016), but whales from different calving areas around Australia and New Zealand likely mix during migration (Carroll et al. 2015). The population size in New Zealand has been estimated at 2169 individuals by 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). 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. 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.

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 North, South, and Stewart Islands. The majority of sightings were made during the winter (59%) and spring (23%), with fewer sightings during summer (7%) and fall (6%). During summer, a single sighting was made on the east coast of North Island in Hawkes Bay; several other sightings were made in Cook Strait, off the northeast and southeast coasts of South Island, and Stewart Island. During spring, 13 sightings were made along the east coast of North Island, including in Hawke's Bay, Bay of Plenty, and along the East Cape; other sightings were made on the south and west coasts of North Island, along the southeast coast of South Island, and south of Stewart Island. Thirty percent of all sightings occurred along the east coast of North Island, the majority of which were made within coastal waters of the East Coast/Hawke's Bay conservancy; sightings were also made in the Bay of Plenty. The area from Hawke's Bay to Bay of Plenty, which includes a portion of the proposed North Island survey area, appears to be a primary calving area for right whales during August–November (Patenaude 2003; Clement 2010).

From 2003 to 2010 there were 125 sightings of right whales around mainland New Zealand; most sightings were made during the winter and spring (Carroll et al. 2014b). The majority of sightings were from South Island, including along the south coast, in Foveaux Strait, and around Stewart Island; concentrations of sightings also occurred along the coast of Northland. Other sightings along the east coast of North Island occurred in the Bay of Plenty, Hawke Bay, East Cape, and off the southeast coast;

sightings were also made in Cook Strait. A total of 38% of sightings along North Island contained cow-calf pairs.

Clement (2010) reported at least 30 sightings for the region between Bay of Plenty and Hawke's Bay since 2008, mainly during the spring along the East Cape headland; although most sightings occurred within the 200-m isobath, a few were made in deeper water. A right whale record for spring also exists for deep water (near the 1000-m isobath) just south of the proposed North Island survey area at ~42.9°S, 174.9°E (Torres et al. 2013b). Berkenbusch et al. (2013) reported 47 sightings for New Zealand during November–March 1970–2013; both spring and summer sightings occurred off the east coast of North Island, Cook Strait, northeastern South Island, Foveaux Strait, Stewart Island, and off the south coast of South Island. During summer and autumn, records are concentrated near the Auckland Islands (Berkenbusch et al. 2013; NZDOC 2017b). Several sightings have been made near the South Island survey area during summer, including in Foveaux Strait, eastern Stewart Island, east of the Snares Islands, and between the Snares and Auckland Islands (NZDOC 2017b).

According to Richards (2009), 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. 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. Up to 1 August 2009, more than 50 sightings had been made off North and South Islands. In addition, there have been at least two strandings of southern right whales in New Zealand (Berkenbusch et al. 2013).

Habitat use (Torres et al. 2013c) and suitability modeling (Patiño-Pérez 2015) for New Zealand showed that a large proportion of the proposed North and South Island survey areas (mainly in deeper water) has low habitat suitability for the southern right whale; sheltered coastal areas had the highest habitat suitability, especially in Foveaux Strait between South and Stewart Islands. Torres et al. (2013a,d) reported that southern right whale presence increases where water temperatures are 7–13°C, with closer proximity to the subtropical front, and a mixed layer depth of <100 m.

The available information suggests that southern right whales could be migrating near or within the proposed survey areas during October–March, with the possibility of some individuals calving in nearshore waters off eastern North Island during November. During the austral summer, most of the population likely occurs further south. Given their primarily nearshore distribution, southern right whales are likely to be common in nearshore areas during the spring 2-D survey off North Island and the summer 2-D survey off South Island, but they are likely to be uncommon during the summer 2-D survey off North Island.

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 (Kemper 2009; Jefferson et al. 2015). Pygmy right whales appear to be non-migratory, although there may be some movement inshore during spring and summer (Kemper 2002). 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).

Despite the scarcity of sightings, Kemper (2009) noted that the number of strandings indicate that the pygmy right whale may be relatively common in Australia and New Zealand. There have been at least 56 strandings in New Zealand, including at least eight live strandings; 4 on the west coast of North Island, 2 in Cook Strait, 1 on the east coast of South Island, and 1 at Stewart Island. (Kemper et al. 2013). Berkenbusch et al. (2013) reported a total of 11 live strandings. Stewart Island, Cook Strait, and the Auckland area on the North Island are considered stranding hotspots in New Zealand (Kemper et al. 2013); strandings have also been reported for Hawke's Bay and the south coast of South Island (Kemper 2002; Kemper et al. 2013). 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). Records have been made throughout the year, but appear to be more frequent during austral spring and summer (Kemper et al. 2013).

Despite the scarcity of sightings, it is possible that this species could be encountered during the proposed surveys off the North or South Islands.

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all oceans of the world (Clapham 2009), with recent genetic evidence suggesting three separate subspecies: North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). Although considered to be mainly a coastal species, they often traverse oceanic areas while migrating (Jefferson et al. 2015). Humpbacks migrate from winter breeding areas in the tropics to temperate or polar feeding areas in the summer (Jefferson et al. 2015). 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; Bettridge et al. 2013). Whales from Oceania migrate past New Zealand to Antarctic summer feeding areas (Constantine et al. 2007; Garrigue et al. 2000, 2010); migration from eastern Australia past New Zealand has also been reported (Franklin et al. 2014).

The northern migration along the New Zealand coast occurs from May to 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 the IWC breeding stock E (Constantine et al. 2007). Constantine et al. (2012) provided a population estimate of 4329 individuals for Oceania.

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 northeast coast of South Island, and Cook Strait. Over half of the total sightings were made during May–August off the eastern coast of South Island (Gibbs and Childerhouse 2000). Gibbs and Childerhouse (2000) also reported numerous humpback records for the east coast of North Island, including the Bay of Islands, Hauraki Gulf, and the Bay of Plenty.

Since 1999, at least 30 additional sightings have been made between Hawke's Bay and Bay of Plenty (Clement 2010); additional sightings in Hawke's Bay and Bay of Plenty have been reported by Berkenbusch et al. (2013) and NZDOC (2017b). Most sightings in the Bay of Plenty occurred from August to January, within and beyond the 200-m isobath (Clement 2010). Clement (2010) reported that humpbacks have been observed feeding in the Bay of Plenty before migrating south for the summer. Sightings in the coastal waters of East Cape were made in June and July; one sighting was made far offshore. 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 East Cape during fall migration.

Torres et al. (2013b) reported one summer humpback whale sighting just south of the North Island survey area near the 2000-m isobath at ~42.7°S, 174.6°E, and several other humpback sightings south of the North Island survey area during spring, summer, and autumn. 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). In addition, there have been at least 20 humpback whale strandings in New Zealand (Berkenbusch et al. 2013).

Off the south coast of South Island, including Foveaux Strait and Stewart Island, sightings have mainly been reported for autumn and winter; sightings within the proposed South Island survey area, between Stewart Island and the Auckland Islands, have mainly been reported during spring (Berkenbusch et al. 2013; NZDOC 2017b). Few records have been reported near the proposed South Island survey area during summer; one record exists for east of Stewart Island and four for the southern Fiordland coast (NZDOC 2017b).

It is likely that some humpback whales would be encountered in the survey area during November and December, as they migrate from winter breeding areas in the tropics to summer feeding grounds in the Antarctic. Fewer humpbacks are expected to occur in the proposed survey areas during January through March, as most individuals occur further south during the summer.

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

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2009). It is one of the least known large baleen whales, and it remains uncertain how many species are represented in this complex (Kato and Perrin 2009). Bryde's whale remains in warm (>16°C) water year-round, and seasonal movements towards the Equator in winter and offshore in summer have been recorded (Kato and Perrin 2009).

In New Zealand, Bryde's whale distribution is largely restricted to warmer waters north of East Cape, North Island (Baker 1999), within 33 km of the coast in water depths <60 m (Wiseman 2008). The west and southeast coast of North Island are not included in the species range description (NABIS 2017), although there are several records for the west coast of North Island (e.g., Torres 2012; Berkenbusch et al. 2013). Patiño-Pérez (2015) included the area from Hawke's Bay to Bay of Plenty as relatively highly suitable habitat. 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; Baker and Madon 2007; Wiseman 2008; Wiseman et al. 2011; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Baker et al. 2010, 2016a; Patiño-Pérez 2015). In Hauraki Gulf, peak numbers occur in winter and breeding takes place during the summer and fall (Wiseman 2008; Wiseman et al. 2011). Vocalizations have also been detected year-round off Great Barrier Island, northern New Zealand, during 1997 (McDonald 2006). Berkenbusch et al. (2013) reported one sighting in offshore waters southeast of New Zealand and 33 strandings for New Zealand during 1970–2013; strandings have been reported along East Cape and Mahia Peninsula (Clement 2010). Constantine et al. (2015) reported 44 mortalities from 1996 to 2014, including 17 vessel strikes and three entanglements, most of these in the Hauraki Gulf. The population for New Zealand has been estimated at 159 individuals (Wiseman 2008).

Bryde's whale is likely to occur in the Bay of Plenty in the proposed North Island survey area; it is unlikely to occur anywhere else in the North Island or South Island survey areas.

Common (*Balaenoptera acutorostrata*) and Antarctic (*B. bonaerensi*) Minke Whales

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. 2015). Its distribution in the Southern Hemisphere is not well known (Jefferson et al. 2015). 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 69°S (Jefferson et al. 2015) 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. 2015). 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; Patiño-Pérez 2015). 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. Gaborit-Haverkamp (2012) reported four sightings in the Bay of Plenty during spring. 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, 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). One sighting has been made in the proposed South Island survey area during winter, one winter sighting was reported for Stewart Island, one spring sighting was reported east of the Auckland Islands, and one summer sighting was made just to the south of the survey area (Berkenbusch et al. 2013). Several additional sightings for waters near and east of Stewart Island and east of the Auckland Islands are reported in the New Zealand sightings and strandings database, but none during summer (NZDOC 2017b). From 1970 to 2013, there were 85 strandings of dwarf minke whales in New Zealand, including 34 live strandings (Berkenbusch et al. 2013). Strandings have occurred along North Island, including Hawke's Bay, Cook Strait, and Bay of Plenty, as well as the east coast of South Island (Brabyn 1991). In addition, 17 Antarctic minke whales stranded in New Zealand from 1970 to 2013, including 10 live strandings (Berkenbusch et al. 2013).

Minke whales, particularly common minke whales, could be encountered during the proposed surveys. Antarctic minke whales would be less likely to be encountered during the time of the proposed surveys, because they would be in their summer feeding areas farther south.

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 whales 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; Patiño-Pérez 2015). Although most sightings have been made during October–April (Clement 2010), there are records of this species throughout the year (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; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Patiño-Pérez 2015; NZDOC 2017b); 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; Patiño-Pérez 2015). One sighting of three individuals was made along the 100-m isopleth off the southeast coast of North Island at ~40.6°S, 176.6°E, in May 2013 (NZDOC 2017b). 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 Island (see Clement 2010; Berkenbusch et al. 2013; Patiño-Pérez 2015). Spring and summer sightings have been reported for the east coast of North Island, including the Bay of Plenty, the Chatham Rise area, east of Stewart Island, as well as other areas around New Zealand (Berkenbusch et al. 2013; Torres et al. 2013b; NZDOC 2017b). 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 areas during October–March.

Fin Whale (*Balaenoptera physalus*)

The fin whale is widely distributed in all the world's oceans, but is most abundant in temperate and cold waters (Aguilar 2009). However, its overall range and distribution is not well known (Jefferson et al. 2015). 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; NZDOC 2017b), 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 sightings have occurred in and near the proposed survey areas off the east coast of North Island during spring and summer (see Clement 2010; 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, Cook Strait, and near Otago Peninsula (Brabyn 1991). There is one record from the proposed South Island survey area, in February, from roughly 125 km south of Snares Island (NZDOC 2017b).

Fin whales could be encountered during the proposed survey, as they migrate to summer feeding areas in lower latitudes.

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. 2015). 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; Patiño-Pérez 2015; Torres and Klinck 2016). Most sightings off the east coast of North Island, including at East Cape and Bay of Plenty, have occurred during spring and summer (Clement 2010; Berkenbusch et al. 2013; Torres 2013; Gaborit-Haverkamp 2012). Torres et al. (2013b) reported a blue whale sighting during summer near the proposed North Island survey area at ~42.4°S, 176°E and one to the south, on the Chatham Rise, during fall. At least one sighting was made during a seismic survey off Cape Palliser (Blue Planet Marine 2016). Olson et al. (2015) reported spring sightings in Hauraki Gulf on the North Island and near Kaikoura on the South Island; other sightings occurred in Cooke Strait, off the east coast of South Island, and southeast of Stewart Island.

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). Feeding has been reported in Hauraki Gulf, off the northwest coast of South Island including South Taranaki Bight, and off the southeast coast of South Island (Olson et al. 2015; Torres et al. 2015; Torres and Klinck 2016). Torres (2013) also noted concentrations of sightings on the east coast of Northland. In addition, several records, including summer sightings, have been reported for Foveaux Strait and off the southeast coast of South Island (Berkenbusch et al. 2013; NZDOC 2017b). One sighting was made southeast of the Snares Islands (Miller et al. 2014a). 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).

Blue whale calls have been detected in New Zealand waters year-round (Miller et al. 2014a). Vocalizations have been recorded within 2 km from Great Barrier Island, northern New Zealand, from June to December 1997 (McDonald 2006), as well as off the tip of Northland (Miller et al. 2014a). Blue whale vocalizations were also detected along the west and east coasts of South Island during January–March 2013; these included songs detected in four locations off the southwest tip of the South Island in early February and at multiple locations south of Stewart Island in mid-March (Miller et al 2014a). Southern Ocean blue whale songs were detected further offshore during May–July (McDonald 2006).

Based on the available information, it is possible that pygmy blue whales could be encountered in the proposed survey areas during October–March.

Odontocetes

Sperm Whale (*Physeter macrocephalus*)

Sperm whales have an extensive worldwide distribution, from the edge of the polar pack ice in both hemispheres to the Equator (Whitehead 2009). Their distribution 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; Patiño-Pérez 2015; NZDOC 2017b). Habitat suitability modeling has shown relatively high suitability of offshore areas of New Zealand, including the deeper waters of the proposed survey area and Cook Strait (Patiño-Pérez 2015). 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; 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 North Island survey area, including the Bay of Plenty and off East Cape (Clement 2010; Berkenbusch et al. 2013; Torres et al. 2013b; Blue Planet Marine 2016; NZDOC 2017b), as well as in and near the South Island survey area (Berkenbusch et al. 2013; NZDOC 2017b). Although sightings have been made during the summer in the proposed North Island survey area, no summer sightings were reported for the South Island survey area. However, sightings were made just to the south of the proposed survey area during summer (Kasamatsu and Joynce 1995). There have been at least 211 strandings reported for New Zealand (Berkenbusch et al. 2013), including along the coast of East Cape, in Hawke's Bay, Cook Strait, and along the south coast of South Island (Brabyn 1991; NZDOC 2017b).

Sperm whales could be encountered during the proposed surveys in October–March.

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 relatively common in those waters (Clement 2010). From 1970 to 2013, 355 strandings were reported, nearly half of which (154) were live strandings (Berkenbusch et al. 2013). More recently, Baker et al. (2016a) reported a total of 418 strandings. 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). Although several strandings have been reported for the east coast of South Island, no strandings have been reported for the southern coast (Brabyn 1991). Half of all female strandings at Hawke's Bay involved calves, suggesting that this area is an important calf rearing 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 North Island survey area but are less likely to occur in the South Island survey area.

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 proposed survey area (MacLeod et al. 2006; Thompson et al. 2013a). Beaked whale sightings in New Zealand primarily consist of *Mesoplodon* spp. and Cuvier's beaked whales. Most sightings are from south and east of South Island (MacLeod and Mitchell 2006), with some sightings of Cuvier's beaked whales 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). For the North Island, strandings have been reported for the Bay of Plenty, East Cape, Mahia Peninsula, Hawke's Bay, as well as Cook Strait; strandings have occurred along all coasts of South Island (Brabyn 1991; Clement 2010; Thompson et al. 2013a). Strandings have been reported throughout the year, with a peak during fall (Thompson et al. 2013a).

Cuvier's beaked whale could be encountered in the deeper offshore areas during the proposed surveys.

Arnoux's Beaked Whale (*Berardius arnuxii*)

Arnoux's beaked whale is distributed in deep, temperate and subpolar waters of the Southern Hemisphere, with most records for southeast South America, the Antarctic Peninsula, South Africa, New Zealand, and southern Australia (Jefferson et al. 2015). It typically occurs south of 40°S, but it could reach latitudes of 34°S or even farther north (Jefferson et al. 2015). Arnoux's beaked whale strands frequently in New Zealand (Ross 2006), with strandings reported for the northwest coast of North Island, Bay of Plenty, Hawke's Bay, and Cook Strait (Clement 2010; Thompson et al. 2013a). MacLeod et al. (2006) reported numerous strandings of *Berardius* spp. for New Zealand. One sighting has been made in the Bay of Plenty (Clement 2010). There have been several sightings in Doubtful Sound, on the southwestern coast of the South Island (NZDOC 2017b) and one stranding in Foveaux Strait (Thompson et el. 2013a).

Arnoux'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. 2015). It is apparently migratory, occurring in Antarctic waters during summer (Jefferson et al. 2015). 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 six sightings have been reported for waters around New Zealand, including one in Hauraki Gulf, one on the southwest coast of South Island, one off the east coast of North Island within the proposed survey area, one off the Otago Peninsula, and two sightings south of New Zealand within the EEZ (Berkenbusch et al. 2013; NZDOC 2017b). In addition, 24 strandings were reported for New Zealand between 1970 and 2013 (Berkenbusch et al. 2013). Strandings have been reported for Bay of Plenty, East Cape, Hawke's Bay, southern North Island, northeastern South Island, and Cook Strait (Brabyn 1991; Clement 2010; Thompson et al. 2013a).

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. However, only a few sightings of live animals have been reported for New Zealand (MacLeod and Mitchell 2006). One possible sighting was made near Christchurch (Watkins 1976). In 2016, there were two sightings of Shepherd's beaked whale on a winter survey offshore from the Otago Peninsula on the South Island (NZDOC 2017b). At least 20 specimens have stranded on the coast of New Zealand (Baker 1999), including in southern Taranaki Bight and Banks Peninsula (Brabyn 1991). Stranding records also exist for Mahia Peninsula and northeastern North Island (Thompson et al. 2013a).

Shepherd'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, Cook Strait, and the east coast of South Island (Brabyn 1991; Clement 2010; Thompson et al. 2013a; NZDOC 2017b).

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

True's Beaked Whale (*Mesoplodon layardii*)

True's beaked whale has a disjunct, antitropical distribution in the Northern and Southern hemispheres (Jefferson et al. 2015). In the Southern Hemisphere, it is known to occur in the Atlantic and Indian oceans, including Brazil, South Africa, Madagascar, and southern Australia (Jefferson et al. 2015). There is a single record of True's beaked whale in New Zealand, which stranded on the west coast of South Island in November 2011 (Constantine et al. 2014).

True's beaked whale is unlikely to 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. 2015). 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 proposed survey area (MacLeod et al. 2006; Thompson et al. 2013a). 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). There are two sightings south of the Aukland Islands (Dalebout et al. 2004). Gray's beaked whale is the most common beaked whale to strand in New Zealand (Berkenbusch et al. 2013), with at least 253 records (Thompson et al. 2013a). Most strandings have been reported for December–May (Thompson et al. 2013a). Stranding records exist along the east coasts of North and South Islands, including Northland, Bay of Plenty, Mahia Peninsula, Hawke's Bay, Cook Strait, and Otago Peninsula; one stranding was reported for Stewart Island (Brabyn 1991; Clement 2010; Thompson et al. 2013a).

Gray'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. 2015). 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, Cook Strait, and southeast of Stewart Island (Brabyn 1991; Clement 2010; Thompson et al. 2013a).

Andrew's 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. 2015). 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 adjacent to the proposed survey area (MacLeod et al. 2006; Clement 2010; Thompson et al. 2013a). 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; Thompson et al. 2013a). 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, Cook Strait, the Otago Peninsula and along Foveaux Strait (Brabyn 1991; Clement 2010; Thompson et al. 2013a).

The strap-toothed 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. 2015). It has the widest distribution throughout the world of all *Mesoplodon* species (Mead 1989b). In the western Pacific, strandings have been reported from Japan to Australia and New Zealand (MacLeod et al. 2006). There have been at least four strandings of Blainville's beaked whale in New Zealand, including three strandings for the northwest coast of North Island and another for Hawke's Bay, but none for the South Island (Thompson et al. 2013a).

Blainville'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 is unlikely to 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. 2015). 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). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2009).

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 2017). The inshore form has three main areas of distribution in New Zealand, including Northland, Marlborough Sounds, and Fiordland (Tezanos-Pinto et al. 2009; NABIS 2017). 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). The offshore form is more widely distributed throughout New Zealand (Baker et al. 2010); off eastern Northland it can be seen during the summer and autumn (NABIS 2017). Baker et al. (2016a) noted that there are likely <1000 bottlenose dolphins in New Zealand waters.

Clement (2010) noted that in general, bottlenose dolphins in New Zealand occur closer to shore during summer and autumn, and farther offshore during winter. Sightings of bottlenose dolphins have been made in shelf and deeper waters (>200 m) off the east coast of North Island throughout the year, including Bay of Plenty, East Cape, Mahia Peninsula, Cape Palliser, and Cook Strait (Clement 2010; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Torres et al. 2013b; Patiño-Pérez 2015; Blue Planet Marine 2016; NZDOC 2017b; SIO n.d.). Torres et al. (2013b) also reported several offshore sightings at Chatham Rise. Habitat suitability modeling by Patiño-Pérez (2015) showed highly suitable habitat in the Bay of Plenty, and moderate-high habitat in the area from Hawke's Bay to eastern Bay of Plenty.

Sightings from the lower South Island are mostly from the Fiordland population (Brough et al. 2015); however, there are also numerous sightings from the south coast, including Foveaux Strait and Stewart Island (Berkenbusch et al. 2013; Brough et al. 2015; NZDOC 2017b). Photo-identification surveys from Stewart Island indicate that these dolphins do not overlap with the Fiordland population (Brough et al. 2015). This may represent a wide ranging southern population with a minimum population of 92; individuals from Stewart Island were resighted in Dusky Sound and Otago Harbour (Brough et al. 2015). One sighting has also been made southeast of the Snares Islands; although sightings have been made near the proposed South Island survey area, none have been reported within it (NZDOC 2017b). Sightings have been reported off the South Island throughout the year (Berkenbusch et al. 2013; NZDOC 2017b). Habitat suitability modeling by Patiño-Pérez (2015) showed moderate to high habitat suitability for the south coast of South Island, including Foveaux Strait and west of Stewart Island. In addition, a total of 157 strandings were reported between 1970 and 2013 for New Zealand (Berkenbusch et al. 2013), including East Cape, Mahia Peninsula, Cook Strait, and Foveaux Strait (Brabyn 1991; Clement 2010).

As sightings have been made in the proposed study areas during the austral spring and summer, it is likely that bottlenose dolphins would be encountered during the surveys during October–March.

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found in tropical to cool temperate oceans around the world, and ranges as far south as ~40°S (Perrin 2009). It is generally considered an oceanic species (Jefferson et al. 2015), but Neumann (2001) noted that this species can be found in coastal and offshore 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 2017) 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 coasts of Northland, Hauraki Gulf, Mahia Peninsula, Cape Palliser, Cook Strait, Marlborough Sounds, and the northwest coast of South Island (NABIS 2017).

The short-beaked common dolphin is likely the most common cetacean species in New Zealand waters, occurring there year-round (Clement 2010; Hutching 2015). 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 within the proposed survey areas (Clement 2010; Berkenbusch et al. 2013; Torres et al. 2013b; Patiño-Pérez 2015; Blue Planet Marine 2016; NZDOC 2017b). However, it is more common off the North Island than the South Island (Berkenbusch et al. 2013; NZDOC 2017b). Clement (2010) reported that areas of frequent sightings occur in the Bay of Plenty, offshore waters off East Cape, and just to the south of Mahia Peninsula, especially during fall and summer. In the Bay of Plenty, encounter rates were highest during summer, followed by autumn, and spring; most sightings were made in water <50 m deep (Gaborit-Haverkamp 2012). 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 within the North Island and South Island survey areas during austral spring and summer, this species is likely to be encountered during the proposed surveys.

Dusky Dolphin (*Lagenorhynchus obscurus*)

The dusky dolphin is found throughout 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, and southwestern Africa (Jefferson et al. 2015). 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 2015) 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 2017); they are rarely seen north of East Cape (Baker 1999). Concentration hotspots include Marlborough Sounds, the northeastern coast of South Island, particularly around Kaikoura, Otago Peninsula, and Fiordland (NABIS 2017). 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 dolphins typically move into deeper waters during the winter. Sightings have been made in and near the proposed North and South Island survey areas during summer (see Clement 2010; Berkenbusch et al. 2013; Patiño-Pérez 2015; Blue Planet Marine 2016; NZDOC 2017b). Some sightings in the austral spring and summer have been made along Northland, Bay of Plenty, off East Cape, southeast coast of North Island, Cape Palliser, and Cook Strait (Berkenbusch et al. 2013; NZDOC 2017b). However, sightings off the entire coastline of South Island appear to be more common and are made throughout the year. Increased densities occur in the northern part of the proposed survey area along the Fiordland coast (NABIS 2017). Sightings within the proposed survey area have been made to the west of Stewart Island, near the Snares Islands, and between the Snares and Auckland Islands (Berkenbusch et al. 2013; NZDOC 2017b). Several sightings have been made along the 500-m isobath on the Chatham Rise (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 is likely to be encountered during the proposed surveys, especially off the South Island.

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) noted 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, two within the proposed South Island survey, and one southwest of the Auckland Islands. 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 North survey area and uncommon in the South Island survey area.

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. 2015). It is sighted most often in cool, offshore waters, although it is sometimes seen near shore where coastal waters are deep (Jefferson et al. 2015).

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 2017). Several more sightings have also been reported off the southeast coast of South Island (NZDOC 2017b).

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 strandings were also reported for Hawke's Bay, southeast North Island, Banks Peninsula, and Foveaux Strait (Clement 2010; NZDOC 2017b).

The southern right whale dolphin could be encountered during the proposed North or South Island surveys.

Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is distributed worldwide in temperate and tropical oceans (Baird 2009a), although it shows a preference for mid-temperate waters of the shelf and slope between 30° and 45° (Jefferson et al. 2014). Although it is known to occur in coastal and oceanic habitats (Jefferson et al. 2014), it appears to prefer steep sections of the continental shelf, 400–1000 m deep (Baird 2009a) and is known to frequent seamounts and escarpments (Kruse et al. 1999).

According to Jefferson et al. (2014, 2015), the range of the Risso's dolphin includes the waters of New Zealand, although the number of records for that region is small. Nonetheless, a few records exist for the North Island, including the east coast (Clement 2010; Berkenbusch et al. 2013; Jefferson et al. 2014). Although some sightings have been reported in New Zealand, such as in South Taranaki Bight on the west coast of North Island (Torres 2012), only strandings are known for the east coast of North Island

(Clement 2010). One stranding has been reported for the northwest coast of South Island (NZDOC 2017b).

Risso's dolphin could be encountered during the proposed surveys.

Hector's (*Cephalorhynchus hectori hectori*) and Maui's (*C. h. maui*) Dolphins

Hector's and Maui's dolphins are endemic to New Zealand and have one of the most restricted distributions of any cetacean (Dawson and Slooten 1988); they occur in New Zealand waters year-round (Berkenbusch et al. 2013). Hector's dolphin (*C. h. hectori*) occurs primarily around South Island, while Maui's dolphin (*C. h. maui*) is restricted to the northwest coast of North Island, from North Taranaki Bight northward (Baker et al. 2002). The population size of Maui's dolphin is estimated at just 55–63 individuals (Hamner et al. 2014; Baker et al. 2016b). Long-distance (<400 km) dispersal has been demonstrated in the species, and occasional sightings have been made off the eastern coast of North Island (Berkenbusch et al. 2013; Torres et al. 2013c; Patiño-Pérez 2015; NZDOC 2017b). Slooten (2013) included the coastal waters of the southeast coast of North Island (south of Hawke's Bay) as part of its range. It is unknown, however, whether these individuals are from the South Island or the North Island populations (Clement 2010).

There are at least three genetically separate populations of Hector's dolphin off South Island: off the east coast (particularly around Banks Peninsula), off the west coast, and off the Southland coast of southern South Island (Baker et al. 2002). Hector's dolphins occur in coastal waters (Slooten et al. 2006). During summer on the east coast, Hector's dolphins tend to aggregate in shallow waters close to shore (Rayment et al. 2006, 2010; NZDOC 2007; Weir and Sagnol 2015). During winter, the distribution extends farther offshore, up to 37 km on shallow shelf areas (Slooten et al. 2005; Rayment et al. 2006; MacKenzie and Clement 2014, 2016). In general, Hector's dolphin prefers water <90 m deep (Bräger et al. 2003; Rayment et al. 2006; Slooten et al. 2006) within 10 km from shore (Hutching 2015). However, several offshore sightings in water deeper than 90 m have been made off the east coast of South Island (MacKenzie and Clement 2014, 2016), and off Mahia Peninsula on the east coast of North Island (Berkenbusch et al. 2013). According to Hutching (2015), Hector's dolphin has been sighted as far as 60 km from shore. Sightings have been made in shallow (<100 m) water adjacent to the proposed North Island survey area, including in the Bay of Plenty, off East Cape, and in Hawke's Bay (Berkenbusch et al. 2013; Torres et al. 2013c). A population of Hector's dolphins is found along the South Island south coast, ranging from approximately Fiordland to Catlins Coast (NZDOC 2007). Concentrations are found in Te Waewae Bay and along Catlins Coast (Green et al. 2007; NZDOC 2007; NABIS 2017). There are also two records for the Stewart Island-Snares Islands shelf and one for the Auckland Islands shelf (NZDOC 2017b).

In addition, there have been at least 249 strandings of Hector's dolphin in New Zealand (Berkenbusch et al. 2013). There have been strandings of Maui's dolphin all along the northwest coast of the North Island as well as one from the South Taranaki Bight and one from the Hauraki Gulf (NABIS 2017). Habitat use (Torres et al. 2013c) and suitability modeling (Patiño-Pérez 2015) showed that some nearshore waters of the northeast coast of South Island and east coast of North Island (including the Bay of Plenty) have moderate to high habitat suitability for Hector's dolphin; moderate to high habitat suitability was reported for nearshore waters along the south coast of South Island, including Foveaux Strait. The highest habitat suitability occurred in shallow, coastal waters along the east and west coasts of South Island (Torres et al. 2013c; Patiño-Pérez 2015). Suspended particulate matter, dissolved organic matter, wave height, and sea surface temperature were important predictors of suitable habitat (Torres et al. 2013c).

Hector's and Maui's dolphins are unlikely to occur in the proposed North Island survey area because of their nearshore distribution and more southerly range. Although Maui's dolphins are not expected to occur in the South Island survey area, Hector's dolphin could be encountered in nearshore waters.

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found in all tropical and warm temperate oceans of the world, with only occasional sightings in cold temperate waters (Baird 2009b). It is known to occur in deep, offshore waters (Odell and McClune 1999), but can also occur over the continental shelf and in nearshore shallow waters (Jefferson et al. 2015; Zaeschmar et al. 2014). In the western Pacific, the false killer whale is distributed from Japan south to Australia and New Zealand.

Berkenbusch et al. (2013) reported 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. Zaeschmar et al. (2014) reported 47 sightings off northeastern New Zealand from 1995 to 2012. Several sightings have been reported for Hauraki Gulf, Bay of Plenty, and East Cape (Clement 2010; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Patiño-Pérez 2015; Zaeschmar 2014; Zaeschmar et al. 2014; NZDOC 2017b). 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). Torres et al. (2013b) reported a sighting southeast of Cape Palliser, near the proposed North Island survey area. A February sighting of 24 individuals southeast of Snares Island, near the proposed South Island survey area, has also been reported, as well as several sightings off the east coast of South Island (Berkenbusch et al. 2013; NZDOC 2017b). In addition, there have been at least 28 strandings in New Zealand (Zaeschmar 2014), including along East Cape, Hawke's Bay, Cape Palliser, Cook Strait, Otago Peninsula, and Catlin's coast (Brabyn 1991; Clement 2010; NZDOC 2017b). The 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; Torres 2012; NABIS 2017). Calves and juveniles 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, 2016a). 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 proposed North Island survey areas, including the Bay of

Plenty, off East Cape, Hawke's Bay, and Cook Strait; sightings have also been made in and near the proposed South Island survey area, including Te Waewae Bay, Foveaux Strait, west and east of Stewart Island, and between Stewart Island and the Auckland Islands (Clement 2010; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Torres et al. 2013b,c; Patiño-Pérez 2015; NZDOC 2017b; SIO n.d). In Hauraki Gulf, encounter rates are highest in spring and lowest in the summer (Hupman et al. 2014). Pods of killer whales are known to frequent Wellington Harbour during the spring and summer (NZDOC 2017a). 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 from the coast (Clement 2010). Habitat suitability modeling suggests that the proposed North Island survey area likely has average to above average habitat suitability for killer whales. Habitat suitability off the south coast of South Island is predicted to be relatively low, with moderate suitability in the northwestern portion of the proposed survey area, including Te Waewae Bay, and in Foveaux Strait (Torres et al. 2013c; Patiño-Pérez 2015). 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 austral spring and summer, killer whales could occur in small numbers near the project areas.

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

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. 2015). Seasonal movements onshore and offshore are related to the distribution of their favored prey item, squid (Olson 2009).

Pilot whales (*Globicephala* sp.) have been sighted in the coastal and offshore waters of New Zealand year-round, including in and near proposed North and South Island survey areas (Clement 2010; Gaborit-Haverkamp 2012; Berkenbusch et al. 2013; Torres et al. 2013b; Patiño-Pérez 2015; Blue Planet Marine 2016; NZDOC 2017b; SIO n.d.). Numerous sightings of long-finned pilot whales have been made within the proposed North Island survey area, especially off the southeast coast of North Island; numerous sightings also exist for the southeast coast of South Island, but none were reported for the proposed South Island survey area (NZDOC 2017b). Sightings were also made south of the South Island survey area during summer (Kasamatsu and Joyce 1995). Short-finned pilot whales have been reported for the east coast of North Island, including the Bay of Plenty and off East Cape, and off the east coast of South Island (NZDOC 2017b).

Pilot whales also commonly strand en masse in New Zealand (Baker 1999; O'Callaghan et al. 2001). The most recent mass stranding (~400 pilot whales) occurred on 10 February 2017 at Farewell Spit on South Island, a known stranding area[3]. Berkenbusch et al. (2013) reported that there have been at least 280 strandings of long-finned pilot whales and at least 12 short-finned pilot whale strandings in New Zealand. Short-finned pilot whale stranding records exist for the Bay of Plenty, East Cape, Hawke's Bay, off Banks Peninsula, and the southeast coast of South Island; strandings of long-finned pilot whales have also been reported along the entire coastline of North and South Islands, including the Bay of Plenty, East Cape, Hawke's Bay, Cook Strait, Banks Peninsula, Otago Peninsula, Catlin's coast, the south coast of South Island, and Stewart Island (Brabyn 1991; Clement 2010; NZDOC 2017b).

[3] https://www.newscientist.com/article/2120967-400-pilot-whales-stranded-on-new-zealands-whale-trap-beach/

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 off the northeast coast of North Island.

Spectacled Porpoise (*Phocoena dioptrica*)

The spectacled porpoise is circumpolar in cool temperate, sub-Antarctic, and low Antarctic waters (Goodall 2009). It is thought to be oceanic in temperate to sub-Antarctic waters and is often sighted in deep waters far from land (Goodall 2009). Little is known regarding the distribution and abundance of the species, but it is believed to be rare throughout most of its range (Goodall and Schiavini 1995). Only five sightings were made during 10 years (1978/79–1987/88) of extensive Antarctic surveys for minke whales (Kasamatsu et al. 1990). An additional 23 at-sea sightings described in Sekiguchi et al. (2006) have expanded the knowledge of the species. The sightings were circumpolar, mostly in offshore waters with sea surface temperatures of 0.9–10.3°C, with a concentration south of the Auckland Islands (Sekiguchi et al. 2006). Sightings have been reported for the west coast of Northland and off the southeast coast of South Island (NZDOC 2017b). Strandings have occurred along the Bay of Plenty, South Taranaki Bight, Banks Peninsula, Otago Peninsula, Catlins Coast, and the Auckland Islands (NZDOC 2017b).

The spectacled porpoise is rare; it is not expected to occur in the proposed North Island survey area but could occur off South Island.

Pinnipeds

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 2017a). It can be found on rocky shores of the mainland, the Chatham Islands, and sub-Antarctic Islands (NABIS 2017; NZDOC 2017a). 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 coasts and islands around South Island, Stewart Island, Solander Island, Snares Islands, and the Auckland Islands (Watson et al. 2015; NABIS 2017); smaller colonies occur on North Island, including the east coast of Cape Palliser, and on the northeast coast of South Island (NABIS 2017). Fur seal distribution hot spots occur along much of the western and southern coasts of South Island, and Stewart and Snares Islands, as well as Cook Strait (NABIS 2017).

Pupping occurs from November to January; in the Bay of Plenty, Cowling et al. (2014) reported pupping during December and January (Cowling et al. 2014). 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 and out beyond the continental shelf, with trips extending more than 150 km from breeding sites and into water depths >1000 m (Harcourt and Davis 1997; Harcourt et al. 2002).

On the east coast of North Island, 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, on East Cape, and in the Bay of Plenty (Clement 2010). In addition, there are also at least two haul-out sites along the northeast coast of South Island (Taylor et al. 1995). Numerous nearshore and offshore sightings have been made within the proposed survey area east of North Island from seismic vessels off the southeast coast of North Island (Blue Planet Marine 2016; SIO n.d.).

There are many haulout and breeding sites along the south coast of South Island, including in Te Waewae Bay and off the west coast of Stewart Island (NABIS 2017). On Otago Peninsula alone, on the southeast coast of South Island, there were 27 breeding and 41 non-breeding sites in 1998 (Bradshaw et al. 2000). Off the west coast of South Island, fur seals are known to occur in water >2000 m deep based on incidental capture in fishing gear; incidental captures were also reported for shelf waters near Snares Islands and the Auckland Islands (Baird 2005). New Zealand fur seals are also known to forage on arrow squid near Snares Islands (Lalas and Webster 2013). Numerous nearshore and offshore sightings have been made off South Island from seismic vessels, including off the southeast coast, east of Stewart Island, and east of Snares Island (Blue Planet Marine 2016). In the sightings database, there are numerous sightings in coastal and offshore waters off the southeast coast of South Island, including Foveaux Strait; there have also been sightings reported near Stewart Island (including just east of the proposed survey area), to the west of Snares Islands (in the proposed survey area), and along the southwest coast of South Island (NZDOC 2014).

New Zealand fur seals would likely be encountered during the proposed surveys off the North and South Islands.

New Zealand Sea Lion (*Phocarctos hookeri*)

The New Zealand sea lion is the only endemic species of pinniped to occur in New Zealand. Although its range used to include the North Island through to Stewart Island, its present day distribution is greatly reduced (Childerhouse and Gales 1998); it is only expected to occur in the proposed survey area off South Island. Its current distribution extends from Southland and Otago Peninsula on South Island south to the subantarctic Campbell Island; concentrations are found along the Otago Peninsula, along Catlins Coast, and around the Auckland Islands (NABIS 2017). The majority of the population breeds in the Auckland Islands (Childerhouse and Gales 1998; Lalas and Webster 2013). Pup production at the Auckland Islands has declined by 50% between 1998 and 2009 (Maloney et al. 2012). The decline was likely due to a combination of disease and bycatch in fisheries (Chilvers et al. 2007). Breeding sites also occur along the southeastern coast of South Island (including Otago Peninsula and Catlins), Stewart Island, Snares Islands, and Campbell Island (Childerhouse and Gales 1998; NZDOC 2009; NABIS 2017). The breeding season begins in November as males establish territories (NZDOC 2009). Females typically arrive in early-December, and the majority of territorial males depart by mid-January (Jefferson et al. 2015). Most pups are born in December and January (NZDOC 2009).

Sea lions that were satellite-tracked in the Auckland Islands during January and February foraged over the entire shelf out to a water depth of 500 m (Chilvers 2009; Meynier et al. 2014) and beyond (Geschke and Chilvers 2009), including near the southeastern-most edge of the proposed survey area. New Zealand sea lions are also known to forage on arrow squid near Snares Islands (Lalas and Webster 2013). Numerous nearshore and offshore sightings have been made off South Island from seismic vessels, including off the southeast coast, east of Stewart Island, and east of Snares Island (Blue Planet Marine 2016).

It is possible that New Zealand sea lions would be encountered during the proposed survey off South Island, but unlikely that they would be encountered in the proposed survey areas off North Island.

Southern Elephant Seal (*Mirounga leonina*)

The southern elephant seal has a near circumpolar distribution in the Southern Hemisphere (Jefferson et al. 2015). However, the distribution of southern elephant seals does not typically extend to the proposed survey areas (NABIS 2017). 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); there are numerous sightings along the southeastern and southwestern coasts of South Island in the marine mammal sightings and strandings database (NZDOC 2017b). 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 northeastern coast of South Island, including Kaikoura Peninsula (Harcourt 2001; van den Hoff 2001; NZDOC 2017b). Individuals have also occurred in the Bay of Plenty and Gisborne (Harcourt 2001); others have been seen in Wellington and other North Island beaches (Daniel 1971), and off Cape Palliser during the austral summer (NZDOC 2017b).

It is possible that elephant seals could be encountered in the proposed survey areas.

Leopard Seal (*Hydrurga leptonyx*)

Leopard seals are found around the Antarctic and in sub-antarctic waters, including most sub-antarctic islands (Jefferson et al. 2015). Although adult seals are typically found near the edge of the pack ice, young animals can travel far throughout the Southern Ocean and occasionally occur in New Zealand, including the Auckland and Campbell Islands, and the mainland (NZDOC 2017a). Numerous sightings have been made along the North and South Islands, not only in the winter but also during January–March (NZDOC 2017b). Sightings for the North Island include Cook Strait, Cape Palliser, the Bay of Plenty, and Hauruki Gulf; there is also one record for offshore waters of the study area off the southeast coast of North Island. For the South Island, sightings have been reported on all coasts, including Forveaux Strait and Stewart Island off the south coast, and in offshore waters off the southeast coast of Stewart Island during January–March.

Leopard seals are unlikely to be encountered during the proposed surveys.

V. Type of Incidental Take Authorization Requested

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

L-DEO requests an IHA pursuant to Section 101 (a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic surveys in the southwest Pacific Ocean in 2017/2018. The operations outlined in § I have the potential to take marine mammals by harassment. Sounds would be generated by the airguns used during the survey, by echosounders, and by general vessel operations. "Takes" by harassment would potentially result when marine mammals near the activity are exposed to the pulsed sounds, such as those generated by the airguns. The effects would depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel.

At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No take by serious injury is expected, given the nature of the planned operations and the mitigation measures that are planned (see § XI, Mitigation Measures), and no lethal takes are expected. However, per NMFS requirement, L-DEO and NSF are also requesting small numbers of Level A takes for the remote possibility of low-level physiological effects. Because of the characteristics of the proposed study and the proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [section V], and the number of times such takings by each type of taking are likely to occur.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock of marine mammal.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Then we summarize the potential impacts of operations by the echosounders. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Finally, we estimate the numbers of marine mammals that could be affected by the proposed surveys in the southwest Pacific Ocean. As called for in § VI, this section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned surveys, as well Level A "takes", as required by NMFS. Acoustic modeling was conducted by L-DEO, determined to be acceptable by NMFS to use in the calculation of estimated takes under the MMPA.

Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.6.4.3, § 3.7.4.3, § 3.8.4.3), 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; Erbe 2012; Peng et al. 2015; Erbe et al. 2015, 2016). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but TTS is not considered 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. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is 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 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 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, 2016; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result 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. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. 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 pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be 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, 2015). 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.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (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. 2013a). 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 (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016).

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 could 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. More recent studies examining the behavioral responses of humpback whales to airguns have also been conducted off eastern Australia (Cato et al. 2011, 2012, 2013, 2016), although results are not yet available for all studies. Dunlop et al. (2015) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun.

A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3 (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Responses to ramp up and use of a 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c).

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). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). 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 2007b).

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 faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011), Atkinson et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

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). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

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, 2015). 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; at SPLs <108 dB re 1 μPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

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.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) and in 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b). Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The 2001 seismic program, as well as a subsequent survey in 2010, involved a comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs of sound above about 163 dB re 1 μPa_{rms} (Johnson et al. 2007; Nowacek et al. 2012, 2013b). The lack of strong avoidance or other strong responses was presumably in part a result of the mitigation measures; effects probably would have been more significant without such intensive mitigation efforts. Gray whales in British Columbia exposed to seismic survey sound levels up to ~170 dB re 1 μPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

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 using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. 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). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

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. In addition, 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 about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about 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; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). 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.

Observations from seismic vessels using large arrays off the U.K. from 1994 to 2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

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* 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). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

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). Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity and periods with airgun operations (Sidorovskaia et al. 2014).

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). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994 to 2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). 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).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013b) 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, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013b). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a

50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 μ$Pa_{0\text{-peak}}$. However, Kastelein et al. (2012c) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013c). The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its 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. NMFS is currently developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioural responses are not consistently associated with received levels, Gomez et al. (2016) recommended that a response/no response dichotomous approach be used when assessing behavioral reactions.

***Pinnipeds*.—**Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994 to 2010 showed that the detection rate for grey seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015). There were no significant differences in CPA distances of grey or harbor seals during seismic vs. non-seismic periods (Stone 2015). Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses; only mild behavioral responses were observed.

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 (reviewed by Southall et al. 2007; Finneran 2015). 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 (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). 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; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a, 2016; Ketten 2012; Supin et al. 2016).

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). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

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. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2016) 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). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016)

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013a,b, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012a) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB (Kastelein et al. 2012a). Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. 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. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed.

Based on the best available information at the time, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1 $\mu Pa^2 \cdot s$ for all cetaceans and 173 dB re 1 $\mu Pa^2 \cdot s$ for pinnipeds in water. For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{eq\text{-}fast}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, according to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. 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 CPA to a seismic vessel is 1 km or more could experience TTS. In addition, Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. 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 possibility 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).

The recently released *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*' (NMFS 2016a) has been used in establishing the EZs (or shut-down zones) planned for the proposed seismic surveys. The new noise exposure criteria for marine mammals account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) 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 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. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

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. 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. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale stranding along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2106). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 62 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2015a). In a hearing to examine the Bureau of Ocean Energy Management's 2017-2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

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, the deep water in the majority of the study areas, 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.

Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed survey. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals appears in § 3.6.4.3, § 3.7.4.3, and § 3.8.4.3 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 linking the operation of an 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. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Reference has also been made that two beaked whales stranded in the Gulf of California in 2002 were observed during a seismic survey in the region by the R/V *Ewing* (Malakoff 2002, Cox et al. 2006 *in* PEIS:3-136), which used a similar MBES system. As noted in the PEIS, however, "The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence" (Hogarth 2002, Yoder 2002 *in* PEIS:3-190).

Lurton (2016) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system like that used on the *Langseth*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioral response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2016:209).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013). Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency active sonars (e.g., Miller et al. 2012; Sivle et al. 2012; Samarra and Miller 2016), mid-frequency active sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012, 2014b; Sivle et al. 2012, 2015; DeRuiter et al. 2013a,b; Goldbogen et al. 2013; Antunes et al. 2014; Baird et al. 2014; Kastelein et al. 2012d, 2015a; Wensveen et al. 2015; Friedlaender et al. 2016; Isojunno et al. 2016; Samarra and Miller 2016), and high-frequency active sonars (Kastelein et al. 2015c,d). 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.

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1 µPa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders 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. Hastie et al. (2014) reported behavioral responses by grey seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2016).

Despite the aforementioned information that has recently become available, and in agreement with § 3.6.7, 3.7.7, and 3.8.7 of the PEIS, the operation of MBESs, SBPs, and pingers is not likely to impact marine mammals, (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 given the movement and speed of the vessel.

Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals 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 *Langseth* could affect marine animals in the proposed survey areas. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise have been shown to affect foraging by porpoise (Teilmann et al. 2015).

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; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2015). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. 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, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016). Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016).

Baleen whales are thought to be more sensitive to sound at these 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 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). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

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 (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Pirotta et al. (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging activity of bottlenose dolphins. Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015).

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, 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. Information on vessel strikes is reviewed in § 3.6.4.4 and § 3.8.4.4 of the PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels (McKenna et al. 2015). The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals 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. There has been no history of marine mammal vessel strikes with the R/V *Langseth*, or its predecessor, R/V *Maurice Ewing* over the last two decades.

Numbers of Marine Mammals that could be "Taken by Harassment"

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. As required by NMFS, Level A takes have been requested; given the very small exclusion zones and the proposed mitigation measures to be applied, injurious takes would not be expected. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious Level A "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 Level B and Level A sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic surveys off the coast of New Zealand in non-Territorial Waters. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

It is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES, SBP, and ADCP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the MBES and SBP given their characteristics (e.g., narrow downward-directed beam) and other considerations described in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS. Such reactions are not considered to constitute "taking" (NMFS 2001). Therefore, no additional allowance is included for animals that could be affected by sound sources other than airguns.

Basis for Estimating "Takes"

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels 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 likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Likewise, they are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) 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 off New Zealand that can be used to estimate species densities, except for Hector's dolphin aerial surveys off the South Island. Densities for Hector's dolphins off the east side of the North Island were estimated using averaged estimated summer densities from the two most northern strata (Golden Bay and Marlborough Sounds) of an East Coast South Island (ECSI) survey in three offshore strata categories (0–4 nm, 4–12 nm, and 12–20 nm; MacKenzie and Clement 2014). The densities used for the two North Island surveys were based on the proportion of each survey occurring in each offshore stratum. Densities for Hector's dolphins off the South Island were estimated using averaged estimated summer densities from the most southern stratum of an ECSI survey (Otago) and a West Coast South Island (WCSI) survey (Milford Sound), both in three offshore strata categories (0–4 nm, 4–12 nm, and

12–20 nm; MacKenzie and Clement 2014, 2016). The density used for the South Island survey was based on the proportion of that survey occurring in each offshore stratum.

For other cetacean species, densities were derived from data available for the Southern Ocean (Butterworth et al. 1994; Kasamatsu and Joyce 1995) and are provided in Table 17. Butterworth et al. (1994) provided comparable data for 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 for these species based on abundances and surface areas provided in Butterworth et al. (1994) and used the mean density for the more recent surveys (1978/79–1987/88) and the 30–40°S and 40–50°S strata because the proposed survey areas are between ~37°S and 50°S. We corrected the densities for mean trackline detection probability, *g*(0) availability bias, using mean *g*(0) values provided for these species during NMFS/SWFSC (Southwest Fisheries Science Centre) ship surveys between 1991–2014 (Barlow 2016). Kasamatsu and Joyce (1995) provided data for beaked whales, killer whale, long-finned pilot whales, and Hourglass dolphins based on the IWC/IDCR (International Whaling Commission/International Decade of Cetacean Research–Southern Hemisphere Minke Whale Assessment Cruises) surveys started in 1978/79 and the Japanese sightings survey programme started in 1976/77. We calculated densities for these species based on abundances and surface areas provided in Kasamatsu and Joyce (1995) for Antarctic Areas V EMN and VI WM, which are the two areas south of the proposed South Island survey area. We corrected the densities for availability bias using mean *g*(0) values provided by Kasamatsu and Joyce (1995) for beaked whales, killer whales, and long-fined pilot whales and Barlow (2016) for the Hourglass dolphin using the mean *g*(0) calculated for unidentified dolphins during NMFS/SWFSC ship surveys between 1991–2014.

For the remaining cetacean species, we then estimated the relative abundance of individual species expected to occur in the survey areas within species groups using various surveys and other information from areas near the survey areas, and general information on species' distributions such as latitudinal ranges and group sizes. Species densities calculated for the Southern Ocean, as described above, for each species group were then averaged, multiplied by the estimated relative abundance of each species and divided by the average estimated relative abundance for the species with known densities being used. The fin, sei, and blue whale densities calculated from Butterworth et al. (1994) were proportionally averaged and used to estimate the densities of the remaining mysticetes. The sperm whale density calculated from Butterworth et al. (1994) was used to estimate the density of the other Physeteridae species, the pygmy sperm whale. The Hourglass dolphin, killer whale, and long-finned pilot whale densities calculated from Kasamatsu and Joyce (1995) were proportionally averaged and used to estimate the densities of the other Delphinidae. For beaked whales, the beaked whale density calculated from Kasamatsu and Joyce (1995) was proportionally allocated according to each beaked whale species' estimated relative abundance value.

For pinnipeds, we used the at-sea density in Bonnell et al. (1992) of northern fur seals based on systematic aerial surveys conducted in 1989–1990 in offshore areas of western U.S. to estimate the numbers of pinnipeds that might be present off New Zealand. The northern fur seal density was used as the New Zealand fur seal density and this value was then prorated to the other pinniped species in accordance to their respective estimated relative abundance values (Table 17).

The estimated numbers of individuals potentially exposed (Level B) are based on the 160-dB re 1 μPa_{rms} criterion for all cetaceans and pinnipeds. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment".

TABLE 17. Estimated densities of marine mammals expected to occur during the North Island and South Island seismic surveys off New Zealand during October 2017–March 2018, based on densities from other regions. Species listed as endangered are in italics. Relative abundance and estimated densities are given for the North Island 2D survey area (NI 2D), North Island 3D survey area (NI 3D), and South Island 2D survey area (SI 2D).

Species	Relative abundance off New Zealand			Density south of 50°S (#/1000 km^2) [1]	Density south of 30°S (#/1000 km^2) [2]	Estimated density off New Zealand (#/1000 km^2) [3]		
	NI 2D	NI 3D	SI 2D			NI 2D	NI 3D	SI 2D
Mysticetes								
Southern right whale	*5*	*5*	*5*			*0.24*	*0.24*	*0.24*
Pygmy right whale	2	2	2			0.10	0.10	0.10
Humpback whale	5	5	4			0.24	0.24	0.19
Bryde's whale	3	3	0			0.14	0.14	0.00
Common minke whale	3	3	3			0.14	0.14	0.14
Antarctic minke whale	3	3	3			0.14	0.14	0.14
Sei whale	*3*	*3*	*3*		*0.14*			
Fin whale	*3*	*3*	*3*		*0.25*			
Blue whale	*3*	*3*	*3*		*0.04*			
All mysticetes	**30**	**30**	**26**					
Odontocetes								
Physeteridae								
Sperm whale	*5*	*5*	*5*		*2.89*			
Pygmy sperm whale	3	3	3			1.74	1.74	1.74
All sperm whales	**8**	**8**	**8**					
Ziphiidae								
Cuvier's beaked whale	3	3	3	2.62				
Arnoux's beaked whale	3	3	3	2.62				
Southern bottlenose whale	2	2	2	1.74				
Shepard's beaked whale	2	2	2	1.74				
Hector's beaked whale	2	2	2	1.74				
True's beaked whale	1	1	1	0.87				
Gray's beaked whale	4	4	4	3.49				
Andrew's beaked whale	2	2	2	1.74				
Strap-toothed whale	3	3	3	2.62				
Blainville's beaked whale	1	1	1	0.87				
Spade-toothed whale	1	1	1	0.87				
All Beaked whales	**24**	**24**	**24**					
Delphinidae								
Bottlenose dolphin	5	5	5			5.12	5.12	4.78
Short-beaked common dolphin	10	10	5			10.25	10.25	4.78
Dusky dolphin	5	5	8			5.12	5.12	7.65
Hourglass dolphin	2	2	3	4.16				
Southern right-whale dolphin	3	3	3			3.07	3.07	2.87
Risso's dolphin	2	2	2			2.05	2.05	1.91
Hector's dolphin	2	1	3			0.11	0	0.04
Maui's dolphin	0	0	0			0	0	0
False killer whale	3	3	3			3.07	3.07	2.87
Killer whale	4	4	4	1.91				
Long-finned pilot whale	8	8	8	8.28				
Short-finned pilot whale	4	4	2			4.10	4.10	1.91
Spectacled Porpoise	0	0	2			0	0	1.91
All Delphinidae	**48**	**47**	**48**					

Species	Relative abundance off New Zealand			Density south of 50°S (#/1000 km^2) [1]	Density south of 30°S (#/1000 km^2) [2]	Estimated density off New Zealand (#/1000 km^2) [3]		
	NI 2D	NI 3D	SI 2D			NI 2D	NI 3D	SI 2D
Pinnipeds								
New Zealand fur seal	10	10	10			22.50	22.50	22.50
Southern elephant seal	2	2	2			4.50	4.50	4.50
New Zealand sea lion	0	0	4			0.00	0.00	9.00
Leopard seal	1	1	1			2.25	2.25	2.25
All Pinnipeds	**13**	**13**	**17**					

[1] Based on data from sighting surveys in the Southern Ocean (south of 50°S) from 1976/77 to 1987/88 (Kasamatsu and Joyce 1995).
[2] Based on Japanese scouting vessel data for the Southern Ocean extrapolated for latitudes south of 30°S from 1965/66–1977/78 and 1978/79–1987/88 (Butterworth et al. 1994).
[3] Pinniped densities based on at-sea northern fur seal densities from Oregon and Washington off the west coast of the U.S. (Bonnell et al. 1992); Hector's dolphin density estimates are from MacKenzie and Clement (2014, 2016).

Tables 18–20 show the density estimates calculated as described above and the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic surveys off the coast of New Zealand if no animals moved away from the survey vessel. Nonetheless, we have included *Requested Take Authorization* for at least 1% of populations in the far right columns of Tables 18–20, for each species for which takes are expected and population sizes are available, as previous surveys in the area have encountered higher numbers of individuals compared to expected densities for some species. It should be noted that the following estimates of exposures assume that the proposed surveys would be completed; in fact, the calculated takes ***have been increased by 25%*** (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to Level B sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

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 §4.1.1.1 of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might 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).

Potential Number of Marine Mammals Exposed to Airgun Sounds

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions have been estimated using a method required by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day (160 km for the 2-D surveys with a long streamer; 200 km for the 3-D survey with short streamers). The 160- or 200-km line(s) selected had a proportion of depth intervals (<100 m, 100–1000 m and >1000 m) with associated radii that was roughly similar to that of the entire survey. The area expected to be ensonified on that day

TABLE 18. Densities and estimates of the possible numbers of individuals that could be exposed to Level B and Level A thresholds during L-DEO's proposed North Island 2-D seismic survey off New Zealand during October–December 2017. 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[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Take Authorization[6]
		Level A[3]	Level B[4]		
LF Cetaceans					
Southern right whale	*0.24*	*2*	*19*	*0.18*	***120***
Pygmy right whale	0.10	1	8	N.A.	**9**
Humpback whale	0.24	2	19	0.05	**420**
Bryde's whale	0.14	1	12	0.03	**481**
Common minke whale	0.14	1	12	<0.01	**7500**
Antarctic minke whale	0.14	1	12	<0.01	**7500**
Sei whale	*0.14*	*1*	*12*	*0.13*	***100***
Fin whale	*0.25*	*2*	*19*	*0.14*	***150***
Blue whale	*0.04*	*0*	*4*	*0.11*	***38***
MF Cetaceans					
Sperm whale	*2.89*	*0*	*245*	*0.82*	***300***
Cuvier's beaked whale	2.62	0	221	0.04	**6000**
Arnoux's beaked whale	2.62	0	221	0.04	**6000**
Southern bottlenose whale	1.74	0	148	0.02	**6000**
Shepard's beaked whale	1.74	0	148	0.02	**6000**
Hector's beaked whale	1.74	0	148	0.02	**6000**
True's beaked whale	0.87	0	74	N.A.	**74**
Gray's beaked whale	3.49	1	294	0.05	**6000**
Andrew's beaked whale	1.74	0	148	0.02	**6000**
Strap-toothed whale	2.62	0	221	0.04	**6000**
Blainville's beaked whale	0.87	0	74	0.01	**6000**
Spade-toothed whale	0.87	0	74	0.01	**6000**
Bottlenose dolphin	5.12	1	432	N.A.	**433**
Short-beaked common dolphin	10.25	2	864	N.A.	**866**
Dusky dolphin	5.12	1	432	3.61	**433**
Southern right-whale dolphin	3.07	1	259	N.A.	**260**
Risso's dolphin	2.05	0	174	N.A.	**174**
False killer whale	3.07	1	259	N.A.	**260**
Killer whale	1.91	0	162	0.20	**800**
Long-finned pilot whale	8.28	1	699	0.35	**2000**
Short-finned pilot whale	4.10	1	346	N.A.	**347**
HF Cetaceans					
Pygmy sperm whale	1.74	5	142	N.A.	**147**
Hourglass dolphin	4.16	12	340	0.23	**1500**
Hector's dolphin	0.11	0	10	0.07	**148**
Maui's dolphin	0	0	0	0	**0**
Spectacled porpoise	0	0	0	0	**0**
Otariids					
New Zealand fur seal	22.50	3	1899	0.95	**2000**
New Zealand sea lion	0	0	0	0	**0**
Phocids					
Southern elephant seal	4.50	2	379	0.06	**6070**
Leopard seal	2.25	1	189	0.09	**2220**

[1] See text for density sources.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 μPa_{rms} on one selected day (see text) outside of territorial waters, multiplied by the number of survey days (35), times 1.25; daily ensonified areas = full 160-dB area (1931.3 km^2) minus ensonified area for the appropriate PTS thresholds (144.5, 3.9, 65.8, 3.1, and 12.0 km^2 for LF cetaceans, MF cetaceans, HF cetaceans, Otariids underwater, and Phocids underwater criteria, respectively).
[3] Level A takes if there were no mitigation measures, based on PTS thresholds.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population; N.A. = population size not available (see Table 16).
[6] Requested takes (Level A+Level B) increased to 1% of population for species for which takes are expected and population size is available.

TABLE 19. Densities and estimates of the possible numbers of individuals that could be exposed to Level B and Level A thresholds during L-DEO's proposed North Island 3-D seismic survey off New Zealand during January–February 2018. 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[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Take Authorization[6]
		Level A[3]	Level B[4]		
LF Cetaceans					
Southern right whale	*0.24*	*0*	*11*	*0.09*	***120***
Pygmy right whale	*0.10*	0	5	N.A.	**5**
Humpback whale	*0.24*	*0*	11	0.03	**420**
Bryde's whale	*0.14*	0	7	0.01	**481**
Common minke whale	*0.14*	*0*	7	<0.01	**7500**
Antarctic minke whale	*0.14*	*0*	7	<0.01	**7500**
Sei whale	*0.14*	*0*	*7*	*0.07*	***100***
Fin whale	*0.25*	*0*	*11*	*0.07*	***150***
Blue whale	*0.04*	*0*	*2*	*0.05*	***38***
MF Cetaceans					
Sperm whale	*2.89*	*1*	*127*	*0.43*	***300***
Cuvier's beaked whale	2.62	0	116	0.02	**6000**
Arnoux's beaked whale	2.62	0	116	0.02	**6000**
Southern bottlenose whale	1.74	0	77	0.01	**6000**
Shepard's beaked whale	1.74	0	77	0.01	**6000**
Hector's beaked whale	1.74	0	77	0.01	**6000**
True's beaked whale	0.87	0	39	N.A.	**39**
Gray's beaked whale	3.49	1	153	0.03	**6000**
Andrew's beaked whale	1.74	0	77	0.01	**6000**
Strap-toothed whale	2.62	0	116	0.02	**6000**
Blainville's beaked whale	0.87	0	39	0.01	**6000**
Spade-toothed whale	0.87	0	39	0.01	**6000**
Bottlenose dolphin	5.12	1	225	N.A.	**226**
Short-beaked common dolphin	10.25	2	450	N.A.	**452**
Dusky dolphin	5.12	1	225	1.88	**226**
Southern right-whale dolphin	3.07	1	135	N.A.	**136**
Risso's dolphin	2.05	0	91	N.A.	**91**
False killer whale	3.07	1	135	N.A.	**136**
Killer whale	1.91	0	85	0.11	**800**
Long-finned pilot whale	8.28	2	363	0.18	**2000**
Short-finned pilot whale	4.10	1	180	N.A.	**181**
HF Cetaceans					
Pygmy sperm whale	1.74	3	74	N.A.	**77**
Hourglass dolphin	4.16	8	175	0.12	**1500**
Hector's dolphin	0	0	0	0	**0**
Maui's dolphin	0	0	0	0	**0**
Spectacled porpoise	0	0	0	0	**0**
Otariids					
New Zealand fur seal	22.50	4	987	0.50	**2000**
New Zealand sea lion	0	0	0	0	**0**
Phocids					
Southern elephant seal	4.50	2	197	0.03	**6070**
Leopard seal	2.25	1	98	0.04	**2220**

[1] See text for density sources.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 μPa_{rms} on one selected day (see text) outside of territorial waters, multiplied by the number of survey days (33), times 1.25; daily ensonified areas = full 160-dB area (1067.3 km^2) minus ensonified area for the appropriate PTS threshold (29.1, 4.5, 47.5, 3.9, and 10.0 km^2 for LF cetaceans, MF cetaceans, HF cetaceans, Otariids underwater, and Phocids underwater criteria, respectively).
[3] Level A takes if there were no mitigation measures, based on PTS thresholds.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population; N.A. = population size not available (see Table 16).
[6] Requested takes (Level A+Level B) increased to 1% of population for species for which takes are expected and population size is available.

TABLE 20. Densities and estimates of the possible numbers of individuals that could be exposed to Level B and Level A thresholds during L-DEO's proposed South Island 2-D seismic survey off New Zealand during February–March 2018. 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[1] (#/1000 km^2)	Calculated Take, NMFS Daily Method[2]		Level A + Level B as % of Pop.[5]	Requested Take Authorization[6]
		Level A[3]	Level B[4]		
LF Cetaceans					
Southern right whale	*0.24*	*1*	*12*	*0.11*	***120***
Pygmy right whale	*0.10*	0	5	N.A.	**5**
Humpback whale	0.19	*1*	9	0.02	**420**
Bryde's whale	0.00	0	0	0	**0**
Common minke whale	0.14	*0*	8	<0.01	**7500**
Antarctic minke whale	0.14	*0*	8	<0.01	**7500**
Sei whale	*0.14*	*0*	*8*	*0.08*	***100***
Fin whale	*0.25*	*1*	*12*	*0.09*	***150***
Blue whale	*0.04*	*0*	*3*	*0.08*	***38***
MF Cetaceans					
Sperm whale	*2.89*	*0*	*153*	*0.51*	***300***
Cuvier's beaked whale	2.62	0	138	0.02	**6000**
Arnoux's beaked whale	2.62	0	138	0.02	**6000**
Southern bottlenose whale	1.74	0	92	0.02	**6000**
Shepard's beaked whale	1.74	0	92	0.02	**6000**
Hector's beaked whale	1.74	0	92	0.02	**6000**
True's beaked whale	0.87	0	46	N.A.	**46**
Gray's beaked whale	3.49	0	184	0.03	**6000**
Andrew's beaked whale	1.74	0	92	0.02	**6000**
Strap-toothed whale	2.62	0	138	0.02	**6000**
Blainville's beaked whale	0.87	0	46	0.01	**6000**
Spade-toothed whale	0.87	0	46	0.01	**6000**
Bottlenose dolphin	4.78	1	251	N.A.	**252**
Short-beaked common dolphin	4.78	1	251	N.A.	**252**
Dusky dolphin	7.65	1	402	3.36	**403**
Southern right-whale dolphin	2.87	0	151	N.A.	**151**
Risso's dolphin	1.91	0	101	N.A.	**101**
False killer whale	2.87	0	151	N.A.	**151**
Killer whale	1.91	0	101	0.13	**800**
Long-finned pilot whale	8.28	1	435	0.22	**2000**
Short-finned pilot whale	1.91	0	101	N.A.	**101**
HF Cetaceans					
Pygmy sperm whale	1.74	4	88	N.A.	**92**
Hourglass dolphin	4.16	10	209	0.15	**1500**
Hector's dolphin	0.04	0	2	0.01	**148**
Maui's dolphin	0	0	0	0	**0**
Spectacled porpoise	1.91	5	96	N.A.	**101**
Otariids					
New Zealand fur seal	22.50	2	1182	0.59	**2000**
New Zealand sea lion	9.00	1	473	4.80	**474**
Phocids					
Southern elephant seal	4.50	2	235	0.04	**6070**
Leopard seal	2.25	1	118	0.05	**2220**

[1] See text for density sources.
[2] Take using NMFS daily method for calculating ensonified area: estimated density multiplied by the daily ensonified area to levels ≥160 dB re 1 μPa_{rms} on one selected day (see text) outside of territorial waters, multiplied by the number of survey days (22), times 1.25; daily ensonified areas = full 160-dB area (1913.4 km^2) minus ensonified area for the appropriate PTS threshold (111.1, 4.1, 86.3, 3.2, and 12.4 km^2 for LF cetaceans, MF cetaceans, HF cetaceans, Otariids underwater, and Phocids underwater criteria, respectively).
[3] Level A takes if there were no mitigation measures, based on PTS thresholds.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population; N.A. = population size not available (see Table 16).
[6] Requested takes (Level A+Level B) increased to 1% of population for species for which takes are expected and population size is available.

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 and PTS threshold buffers around each seismic line. The ensonified areas were then multiplied by the number of survey days (35 days for the North Island 2-D survey, 33 days for the North Island 3-D survey, and 22 days for the South Island 2-D survey) increased by 25%; this is equivalent to adding an additional 25% to the proposed line km. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the *Langseth* approaches.

Per NMFS requirement, estimates of the numbers of cetaceans and pinnipeds that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups, if there were no mitigation measures (power downs or shut downs when PSOs observed animals approaching or inside the EZs), are also given in Tables 18–20. Those numbers likely overestimate actual Level A takes because the predicted Level A EZ is very small and mitigation measures would further chances of, if not eliminate, any such takes. In addition, most marine mammals would move away from a sound source before they are exposed to sound levels that could result in a Level A take. Thus, Level A takes are considered highly unlikely.

North Island 2-D Survey

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the North Island 2-D survey area is 6289 (Table 18). That total includes 304 cetaceans listed under the ESA: 245 sperm whales, 21 fin whales, 21 southern right whales, 13 sei whales, and 4 blue whale, representing 0.82%, 0.14%, 0.18%, 0.13%, and 0.11% of their regional populations, respectively. In addition, 1772 beaked whales could be exposed. Most (90%) of the cetaceans potentially exposed would be MF cetaceans, with estimates of 866 common dolphins and 700 long-finned pilot whales exposed to ≥160 dB re 1 μPa_{rms}. Except for the Dusky dolphin (3.61%), all estimated takes are <1% of their regional populations. The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 1902 otariids and 572 phocids. Most estimated takes are for New Zealand fur seals (0.95% of the population).

North Island 3-D Survey

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the North Island 3-D survey area is 3281 (Table 19). That total includes 159 cetaceans listed under the ESA: 128 sperm whales, 11 fin whales, 11 southern right whales, 7 sei whales, and 2 blue whale, representing 0.43%, 0.07%, 0.09%, 0.07%, and 0.05% of their regional populations, respectively. In addition, 927 beaked whales could be exposed. Most (90%) of the cetaceans potentially exposed would be MF cetaceans, with estimates of 452 common dolphins and 365 long-finned pilot whales exposed to ≥160 dB re 1 μPa_{rms}. Except for the Dusky dolphin (1.88%), all estimated takes are <0.5% of their regional populations. The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 991 otariids and 299 phocids. Most estimated takes are for New Zealand fur seals (0.50% of the population).

South Island 2-D Survey

The estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the South Island 2-D survey area is 3787 (Table 20). That total includes 190 cetaceans listed under the ESA: 153 sperm whales, 13 fin whales, 13 southern right whales, 8 sei whales, and 3 blue whales, representing 0.51%, 0.09%, 0.11%, 0.08%, and 0.08% of their regional populations, respectively. In addition, 1204 beaked whales could be exposed. Most (87%) of the cetaceans potentially exposed would be MF cetaceans, with estimates of 436 long-finned pilot whales and

403 dusky dolphins exposed to ≥160 dB re 1 μPa_{rms}. Except for the Dusky dolphin (3.36%), all estimated takes are <0.6% of their regional populations. The estimate of the number of pinnipeds that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} is 1658 otariids and 356 phocids. Most estimated takes are for New Zealand fur seals and New Zealand sea lions (0.59% and 4.80% of their regional populations, respectively).

Conclusions

The proposed seismic project would involve towing an 18- or 36-airgun array that introduces 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". 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, odontocete, and pinniped species and that Level A effects were highly unlikely. Nonetheless, NMFS required the calculation of and request for potential Level A takes for the Proposed Action (following a different methodology than used in the PEIS and most previous analyses for NSF-funded seismic surveys). For recently NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015b, 2016b,c).

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 Level A and/or B harassment are low percentages of the regional population sizes (Tables 18–20). Although the calculated take estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds, we have increased the requested takes to 1% of the regional population size, where available. Based on experience working in the area and variability of the environmental conditions of the project area, we believe the calculated takes for many species could be too low. However, 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 marine mammals would be anticipated from the proposed activities.

In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The Level B estimates are thought to be conservative; thus, not all animals detected within this threshold distance would be expected to have been exposed to actual sound levels >160 dB.

VIII. Anticipated Impact on Subsistence

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

There is no subsistence hunting near the proposed survey areas, so the proposed activity would not have any impact on the availability of the species or stocks for subsistence users.

IX. Anticipated Impact on Habitat

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

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

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.

X. Anticipated Impact of Loss or Modification of Habitat on Marine Mammals

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations would be limited in duration. However, a small minority of the marine mammals that are present near the proposed activity may be temporarily displaced as much as a few kilometers by the planned activity.

XI. Mitigation Measures

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Marine mammals and sea turtles are known to occur in the proposed survey areas. To minimize the likelihood that impacts would occur to the species and stocks, airgun operations would be conducted in accordance with the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species. The proposed activity would take place in the EEZ of New Zealand, including Territorial Waters.

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity. The procedures described here are based on protocols used during previous L-DEO seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

Planning Phase

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

1. *Energy Source*—Part of the considerations for the proposed marine seismic surveys was to evaluate whether the research objectives could be met with a smaller energy source. For the 2-D surveys, land-based recording stations are hundreds of kilometers away; thus, the airgun source needs to be strong enough to achieve the necessary propagation distances. For the 3-D survey, target depths are ~10 km below the seafloor. The signal from the 18-airgun array is just strong enough to reach these depths and to determine physical conditions. The scientific objectives for the proposed surveys could not be met using smaller sources.
2. *Survey Location and Timing*—The PIs worked with L-DEO and NSF to identify specific locations where seismic activities would not take place, such as in marine protected areas (see § III below), in order to avoid sensitive species and concentrations of marine mammals. When considering potential times to carry out the proposed surveys, key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the *Langseth*.

   Most marine mammal species are expected to occur in the area year-round, but some migratory baleen whales occur in the area on a seasonal basis. Austral spring is the migration period for some baleen whales (e.g., humpbacks, right whales), but it is likely that fewer baleen whales would occur in the region during austral summer, as they typically occur in lower latitudes at that time. In addition, the October to March timeframe for the surveys has more ideal weather conditions resulting in calmer waters than other times of the year, which is necessary for quality data collection. Also the North Island surveys would need to coordinate with the R/V *Tangaroa* (not funded through NSF) which would deploy OBSs in the survey area, and with a land component that includes land seismic stations.
3. *Mitigation Zones*—During the planning phase, mitigation zones for the proposed surveys were calculated based on modeling by L-DEO for both the EZ and the safety zone. The proposed surveys would acquire data with the 18- or 36-airgun array at a maximum tow depth of 9 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve. The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the difference in tow depth between the calibration survey (6 m) and the proposed surveys (9 m). A more detailed description of the modeling process used to develop the mitigation zones can be found in § I.

   NMFS guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a) established new thresholds for PTS onset or Level A Harassment (injury), for marine mammal species. The distances to the PTS thresholds for the various marine mammal hearing groups have been modeled by L-DEO. Enforcement of mitigation zones via power and shut downs would be implemented during operations, as noted below.

Mitigation During Operations

Mitigation measures that would be adopted during the proposed surveys include (1) power-down procedures, (2) shut-down procedures, and (3) ramp-up procedures.

Power-down Procedures

A power down involves decreasing the number of airguns in use such that the radius of the threshold zone is decreased to the extent that marine mammals or turtles are no longer in or about to enter the EZ. The acoustic source would also be powered down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ. During a power down, one airgun would be operated. The continued operation of one airgun is intended to alert marine mammals and turtles to the presence of the seismic vessel in the area. In contrast, a shut down occurs when all airgun activity is suspended.

If a marine mammal or turtle is detected outside the EZ but is likely to enter the EZ, the airguns would be powered down before the animal is within the EZ. Likewise, if a mammal or turtle is already within the EZ when first detected, the airguns would be powered down immediately. During a power down of the airgun array, the 40-in^3 airgun would be operated. If a marine mammal or turtle is detected within or near the smaller EZ around that single airgun, it would be shut down (see next subsection).

Following a power down, airgun activity would not resume until the marine mammal or turtle has cleared the EZ. The animal would be considered to have cleared the EZ if

- it is visually observed to have left the EZ, or
- it has not been seen within the zone for 15 min in the case of small odontocetes, or
- it has not been seen within the zone for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales, or
- the vessel has moved outside the EZ for turtles, e.g., if a turtle is sighted close to the vessel and the ship speed is 8.3 km/h, it would take the vessel ~15 min to leave the turtle behind.

During airgun operations following a shut down whose duration has exceeded the time limits specified above, the airgun array would be ramped up gradually. Ramp-up procedures are described below. During past *Langseth* marine geophysical surveys, following an extended power-down period, the seismic source followed ramp-up procedures to return to the full seismic source level. Under a power-down scenario, however, a single mitigation airgun still would be operating to alert and warn animals of the on-going activity. Furthermore, under these circumstances, ramp-up procedures may unnecessarily extend the length of the survey time needed to collect seismic data. L-DEO and NSF have concluded in consultation with NMFS that ramp up is not necessary after an extended power down. Therefore, this practice is not included here as part of the monitoring and mitigation plan.

Shut-down Procedures

The operating airgun(s) would be shut down if a marine mammal or turtle is seen within or approaching the EZ for the single airgun. The operating airgun(s) would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ.

Shut downs would be implemented (1) if an animal enters the EZ of the single airgun after a power down has been initiated, or (2) if an animal is initially seen within the EZ of the single airgun when more than one airgun (typically the full array) is operating. Airgun activity would not resume until the marine mammal or turtle has cleared the EZ, or until the PSO is confident that the animal has left the vicinity of the vessel. Criteria for judging that the animal has cleared the EZ would be as described in the preceding subsection.

Ramp-up Procedures

A ramp-up procedure would be followed when the airgun array begins operating after a specified period without airgun operations. It is proposed that, for the present survey, this period would be ~8 min. Similar periods (~8–10 min) were used during previous L-DEO surveys. Ramp up would not occur if a marine mammal or sea turtle has not cleared the EZ as described earlier.

Ramp up would begin with the smallest airgun in the array (40 in^3). Airguns would be added in a sequence such that the source level of the array would increase in steps not exceeding 6 dB per 5-min period. During ramp up, the PSOs would monitor the EZ, and if marine mammals or turtles are sighted, a power down or shut down would be implemented as though the full array were operational.

If the complete EZ has not been visible for at least 30 min prior to the start of operations in either daylight or nighttime, ramp up would not commence unless at least one airgun (40 in^3 or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the airgun array would not be ramped up from a complete shut down at night or in thick fog, because the outer part of the EZ for that array would not be visible during those conditions. If one airgun has operated during a power-down period, a return to full power would be permissible at night or in poor visibility, on the assumption that marine mammals and turtles would be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away. Ramp up of the airguns would not be initiated if a sea turtle or marine mammal is sighted within or near the applicable EZs during the day or night.

As noted above under "Power-down Procedures", during past R/V *Langseth* marine geophysical surveys, following an extended power-down period, the seismic source followed ramp-up procedures to return to the full seismic source level. Currently, under a power-down scenario, however, a single mitigation airgun still would be operating to alert and warn animals of the on-going activity and therefore ramp-up is viewed unnecessary.

XII. PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Not applicable. The proposed activity would take place in the southwest Pacific Ocean, and no activities would take place in or near a traditional Arctic subsistence hunting area.

XIII. MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding...

L-DEO proposes to sponsor marine mammal monitoring during the present project, in order to implement the proposed mitigation measures that require real-time monitoring and to satisfy the expected monitoring requirements of the IHA. L-DEO's proposed Monitoring Plan is described below. L-DEO understands that this Monitoring Plan would be subject to review by NMFS and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. L-DEO is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

Observations by PSOs would take place during daytime airgun operations and nighttime start ups of the airguns. Airgun operations would be suspended when marine mammals, turtles, or diving ESA-listed seabirds are observed within, or about to enter, designated EZs [see § XI above] where there is concern about potential effects on hearing or other physical effects. PSOs would also watch for marine mammals and sea turtles near the seismic vessel for at least 30 min prior to the planned start of airgun operations. Observations would also be made during daytime periods when the *Langseth* is underway without seismic operations, such as during transits. PSOs would also watch for any potential impacts of the acoustic sources on fish.

During seismic operations, four visual PSOs (PSVOs) would be based aboard the *Langseth*. All PSOs would be appointed by L-DEO with NMFS concurrence. During the majority of seismic operations, two PSVOs would monitor for marine mammals and sea turtles around the seismic vessel. Use of two simultaneous observers would increase the effectiveness of detecting animals around the source vessel. However, during meal times, only one PSVO may be on duty. PSVO(s) would be on duty in shifts of duration no longer than 4 h. Other crew would also be instructed to assist in detecting marine mammals and turtles and implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew would be given additional instruction regarding how to do so.

The *Langseth* is a suitable platform for marine mammal and turtle observations. When stationed on the observation platform, the eye level would be ~21.5 m above sea level, and the observer would have a good view around the entire vessel. During daytime, the PSVO(s) would scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), and with the naked eye. During darkness, night vision devices (NVDs) would be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), when required. Laser rangefinding binoculars

(Leica LRF 1200 laser rangefinder or equivalent) would be available to assist with distance estimation. Those are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly; that is done primarily with the reticles in the binoculars.

Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) would take place to complement the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Acoustical monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The acoustic monitoring would serve to alert PSVOs (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or by night, and does not depend on good visibility. It would be monitored in real time so that the visual observers can be advised when cetaceans are detected.

The PAM system consists of hardware (i.e., hydrophones) and software. The "wet end" of the system consists of a towed hydrophone array that is connected to the vessel by a tow cable. The tow cable is 250 m long, and the hydrophones are fitted in the last 10 m of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths <20 m. The array would be deployed from a winch located on the back deck. A deck cable would connect the tow cable to the electronics unit in the main computer lab where the acoustic station, signal conditioning, and processing system would be located. The acoustic signals received by the hydrophones are amplified, digitized, and then processed by the Pamguard software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

One acoustic PSO or PSAO, in addition to the four PSVOs, would be on board. The towed hydrophones would ideally be monitored 24 h per day while at the seismic survey areas during airgun operations, and during most periods when the *Langseth* is underway while the airguns are not operating. However, PAM may not be possible if damage occurs to the array or back-up systems during operations. One PSAO would monitor the acoustic detection system at any one time, by listening to the signals from two channels via headphones and/or speakers and watching the real-time spectrographic display for frequency ranges produced by cetaceans. The PSAO monitoring the acoustical data would be on shift for 1–6 h at a time. All observers are expected to rotate through the PAM position, although the most experienced with acoustics would be on PAM duty more frequently.

When a vocalization is detected while visual observations are in progress, the PSAO would contact the PSVO immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), and to allow a power or shut down to be initiated, if required. The information regarding the call would be entered into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection could also be recorded for further analysis.

PSO Data and Documentation

PSOs would record data to estimate the numbers of marine mammals, turtles, and diving ESA-listed seabirds exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. They would also record any observations of fish potentially affected by the sound sources. Data would be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a power or shut down of the airguns when a marine mammal, sea turtle, or diving ESA-listed seabird is within or near the EZ.

When a sighting is made, the following information about the sighting would be recorded:

1. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.
2. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The data listed under (2) would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

All observations and power or shut downs would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program, and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations would provide

1. the basis for real-time mitigation (airgun power down or shut down);
2. information needed to estimate the number of marine mammals potentially taken by
3. harassment, which must be reported to NMFS;
3. data on the occurrence, distribution, and activities of marine mammals, turtles, and diving ESA-listed seabirds in the area where the seismic study is conducted;
4. information to compare the distance and distribution of marine mammals, turtles, and diving ESA-listed seabirds relative to the source vessel at times with and without seismic activity;
5. data on the behavior and movement patterns of marine mammals and turtles seen at times with and without seismic activity; and
6. any observations of fish potentially affected by the sound sources.

A report would be submitted to NMFS and NSF within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals, turtles, and diving ESA-listed seabirds near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, all marine mammal, turtle, and diving ESA-listed seabird sightings (dates, times, locations, activities, associated seismic survey activities), and any observations of fish potentially affected by the sound sources. The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

XIV. Coordinating Research to Reduce and Evaluate Incidental Take

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

L-DEO and NSF would coordinate with applicable U.S. agencies (e.g., NMFS) and would comply with their requirements.

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