



DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648-XA961

Takes of Marine Mammals Incidental to Specified Activities; Low-Energy Marine Geophysical Survey in the South-Eastern Pacific Ocean, May, 2012

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed Incidental Harassment Authorization; request for comments.

SUMMARY: NMFS has received an application from the Scripps Institution of Oceanography (SIO) for an Incidental Harassment Authorization (IHA) to take marine mammals, by harassment, incidental to conducting a low-energy marine geophysical (i.e., seismic) survey in the south-eastern Pacific Ocean, May, 2012. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an IHA to SIO to incidentally harass, by Level B harassment only, 20 species of marine mammals during the specified activity.

DATES: Comments and information must be received no later than [insert date 30 days after date of publication in the FEDERAL REGISTER].

ADDRESSES: Comments on the application should be addressed to P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910. The mailbox address for providing email comments is ITP.Goldstein@noaa.gov. NMFS is not responsible for e-mail comments sent to addresses other than the one provided here. Comments sent via email, including all attachments, must not exceed a 10-megabyte file size.

All comments received are a part of the public record and will generally be posted to

<http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications> without change. All Personal Identifying Information (for example, name, address, etc.) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

A copy of the application containing a list of the references used in this document may be obtained by writing to the above address, telephoning the contact listed here (see FOR FURTHER INFORMATION CONTACT) or visiting the internet at:

<http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications>.

The National Science Foundation (NSF) has prepared a draft “National Environmental Policy Act Analysis Pursuant to Executive Order 12114 of a Marine Geophysical Survey by the R/V Melville in the South-Eastern Pacific Ocean May 2012 (EA).” The draft EA incorporates an “Environmental Analysis of a Marine Geophysical Survey by the R/V Melville in the South-Eastern Pacific Ocean off Chile, May 2012,” prepared by LGL Ltd., Environmental Research Associates (LGL), on behalf of NSF and SIO, which is also available at the same internet address. Documents cited in this notice may be viewed, by appointment, during regular business hours, at the aforementioned address.

FOR FURTHER INFORMATION CONTACT: Howard Goldstein or Jolie Harrison, Office of Protected Resources, NMFS, 301-427-8401.

SUPPLEMENTARY INFORMATION:

Background

Section 101(a)(5)(D) of the MMPA (16 U.S.C. 1371 (a)(5)(D)) directs the Secretary of Commerce (Secretary) to authorize, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by United States citizens who engage in a specified activity (other than commercial fishing) within a specified

geographical region if certain findings are made and, if the taking is limited to harassment, a notice of a proposed authorization is provided to the public for review.

Authorization for the incidental taking of small numbers of marine mammals shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock and its habitat, and requirements pertaining to the mitigation, monitoring and reporting of such takings. NMFS has defined "negligible impact" in 50 CFR 216.103 as "...an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

Section 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. Section 101(a)(5)(D) of the MMPA establishes a 45-day time limit for NMFS's review of an application followed by a 30-day public notice and comment period on any proposed authorizations for the incidental harassment of small numbers of marine mammals. Within 45 days of the close of the public comment period, NMFS must either issue or deny the authorization.

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

Summary of Request

NMFS received an application on December 23, 2011, from SIO for the taking by harassment, of marine mammals, incidental to conducting a low-energy marine seismic survey in the south-eastern Pacific Ocean. SIO, a part of the University of California San Diego, with research funding from the NSF, plans to conduct a low-energy seismic survey in the South-Eastern Pacific Ocean off the coast of Chile during May, 2012, for approximately five to 11 days. The survey will use a pair of Generator Injector (GI) airguns each with a discharge volume of 45 cubic inches (in³). SIO plans to conduct the proposed survey from approximately May 4 to 18, 2012. The proposed seismic survey will be conducted in the Exclusive Economic Zone (EEZ) of Chile. On behalf of SIO, the U.S. State Department will seek authorization from Chile for clearance to work in its EEZ.

SIO plans to use one source vessel, the R/V Melville (Melville) and a seismic airgun array to collect seismic reflection and refraction profiles to monitor the post-seismic response of the outer accretionary prism, the area where sediments are accreted onto the non-subducting tectonic plate at the convergent plate boundary off of the coast of Chile. In addition to the proposed operations of the seismic airgun array, SIO intends to operate a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) continuously throughout the survey.

Acoustic stimuli (i.e., increased underwater sound) generated during the operation of the seismic airgun array may have the potential to cause a short-term behavioral disturbance for marine mammals in the survey area. This is the principal means of marine mammal taking associated with these activities and SIO has requested an authorization to take 20 species of marine mammals by Level B harassment. Take is not expected to result from the use of the MBES or SBP, for reasons discussed in this notice; nor is take expected to result from collision with the vessel because it is a single vessel moving at a relatively slow speed during seismic acquisition within the survey, for a relatively short period of time (approximately five to 11

days). It is likely that any marine mammal would be able to avoid the vessel.

Description of the Proposed Specified Activity

SIO's proposed seismic survey in the south-eastern Pacific Ocean will take place for approximately 5 to 11 days in May, 2012 (see Figure 1 of the IHA application). The proposed seismic survey will take place in water depths ranging from approximately 1,000 to 5,300 meters (m) (3,280.8 to 17,388.5 feet [ft]) and the program will consist of approximately 1,145 kilometers (km) (618.3 nautical miles [nmi]) of seismic survey tracklines (see Figure 1 of the IHA application). The survey will take place in the area approximately 34° to 36° South, 72° to 74° West, off the coast of Chile. The project is scheduled to occur from approximately May 4 to 18, 2012. Some minor deviation from these dates is possible, depending on logistics and weather.

The survey will involve one source vessel, the Melville. For the seismic component of the research program, the Melville will deploy an array of two low-energy Sercel Generator Injector (GI) airguns as an energy source (each with a discharge volume of 45 in³) at a tow depth of 2 m (6.6 ft). The acoustic receiving system will consist of a 200 to 800 m (656.2 to 2,624.7 ft) hydrophone streamer with up to 48 channels with 12.5 m (41 ft) channel spacing, and broadband Ocean Bottom Seismometers (OBSs). The energy to the airguns is compressed air supplied by compressors on board the source vessel. As the airgun is towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system. The OBSs acquire the signal, process the data, and log it internally until the instrument is retrieved and the data is recovered.

SIO plans to use conventional low-energy seismic methodology to monitor the post-seismic response of the outer accretionary prism, the area where sediments are accreted onto the non-subducting tectonic plate at the convergent plate boundary. To provide constraints on the

fault structure and seismic stratigraphy in the accretionary wedge, high resolution seismic data will be acquired using two GI airguns shot simultaneously. Simultaneous shots from both airguns will provide penetration to basement in the trench and clearly define fault structures and folds in the slope basin sediments that overlie the accretionary complex. The primary tracklines, approximately 569 km (307.2 nmi), identified in Figure 1 of the IHA application, will be surveyed first. Depending on the weather, quality and at sea conditions, efforts will be made to survey the secondary tracklines, approximately 576 km (311 nmi), identified in Figure 1 of the IHA application. During the survey OBSs will be deployed and survey profiles will be taken along the tracklines that extend from the trench across the accretionary complex to the region of greatest slip. These data will be processed onboard the vessel and will be used to optimize the location of remaining profiles to be collected within the survey site area. In addition to the operations of the airgun array, a MBES and SBP will also be operated from the Melville continuously throughout the cruise. There will be additional seismic operations associated with equipment testing, start-up, and possible line changes or repeat coverage of any areas where initial data quality is sub-standard. In SIO's calculations, 25% has been added for those contingency operations.

All planned geophysical data acquisition activities will be conducted by technicians provided by SIO, with on-board assistance by the scientists who have proposed the study. The Principal Investigator (PI) is Dr. Anne Trehu of Oregon State University. The vessel will be self-contained, and the crew will live aboard the vessel for the entire cruise.

Vessel Specifications

The Melville is operated by the SIO under a charter agreement with the U.S. Office of Naval Research. The title of the vessel is held by the U.S. Navy. The Melville will tow the two GI airgun array, as well as the hydrophone streamer, along predetermined lines.

The vessel has a length of 85 m (278.9 ft); a beam of 14 m (45.9 ft), and a full load draft of 5.0 m (16.4 ft). The ship is powered by two 1,385 horsepower (hp) propulsion General Electric motors and a 900 hp retracting azimuthing bow thruster. An operations speed of approximately 8 to 12 km/hour (hr) (4 to 6 knots [kt]) and 15 to 18.5 km/hr (8 to 10 kt) will be used during seismic acquisition within the survey areas and between stations, respectively. When not towing seismic survey gear, the Melville cruises at 21.7 km/hr (11.7 kt) and has a maximum speed of 25.9 km/hr (14 kt). The Melville has an operating range of approximately 18,630 km (10,059.4 nmi) (the distance the vessel can travel without refueling).

The vessel will also serve as a platform for which vessel-based Protected Species Observers (PSOs) will watch for marine mammals before and during the proposed airgun operations.

Acoustic Source Specifications

Seismic Airguns

The Melville will deploy and tow an array consisting of a pair of 45 in³ Sercel GI airgun and a streamer containing hydrophones along predetermined lines. Seismic pulses will be emitted at intervals of approximately eight to 12 seconds (s). At speeds of approximately eight to 12 km/hr through the water, the eight to 12 s spacing corresponds to shot intervals of approximately 25 m (82 ft).

The generator chamber of each GI airgun, the one responsible for introducing the sound pulse into the ocean, is 45 in³, depending on how it is configured. The injector chamber injects air into the previously-generated bubble to maintain its shape, and does not introduce more sound into the water. The two GI airguns will be towed 8 m (26.2 ft) apart side-by-side, 21 m (68.9 ft) behind the Melville, at a depth of 2 m (6.6 ft). Depending on the configuration, the total effective volume will be 90 in³ or 210 in³. As a precautionary measure, SIO assumes that the

larger volume will be used.

As the GI airguns are towed along the survey lines, the towed hydrophone array in the streamer receive the reflected signals and transfer the data to the on-board processing system. The OBSs acquire the signal, process the data, and log it internally until the instrument is retrieved and the data is recovered. Given the relatively short streamer length behind the vessel, the turning rate of the vessel while the gear is deployed is much higher than the limit of five degrees per minute for a seismic vessel towing a streamer of more typical length (much greater than 1 km [0.5 nmi]). Thus maneuverability of the vessel is not limited much during operations.

Metrics Used in This Document

This section includes a brief explanation of the sound measurements frequently used in the discussions of acoustic effects in this document. Sound pressure is the sound force per unit area, and is usually measured in micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level (SPL) is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in underwater acoustics is 1 μPa , and the units for SPLs are dB re: 1 μPa . $\text{SPL (in decibels [dB])} = 20 \log (\text{pressure}/\text{reference pressure})$.

SPL is an instantaneous measurement and can be expressed as the peak, the peak-peak (p-p), or the root mean square (rms). Root mean square, which is the square root of the arithmetic average of the squared instantaneous pressure values, is typically used in discussions of the effects of sounds on vertebrates and all references to SPL in this document refer to the root mean square unless otherwise noted. SPL does not take the duration of a sound into account.

Characteristics of the Airgun Sounds

Airguns function by venting high-pressure air into the water which creates an air bubble. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure,

followed by several positive and negative pressure excursions caused by the oscillation of the resulting air bubble. The oscillation of the air bubble transmits sounds downward through the seafloor and the amount of sound transmitted in the near horizontal directions is reduced.

However, the airgun array also emits sounds that travel horizontally toward non-target areas.

The nominal downward-directed source levels of the airgun arrays used by SIO on the Melville do not represent actual sound levels that can be measured at any location in the water. Rather they represent the level that would be found 1 m (3.3 ft) from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns will not exceed the source level of the strongest individual source. In this case, that will be about 234.4 dB re 1 μ Pam peak, or 239.8 dB re 1 μ Pam peak-to-peak. However, the difference between rms and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors.

Accordingly, Lamont-Doherty Earth Observatory of Columbia University (L-DEO) has predicted the received sound levels in relation to distance and direction from the two GI airgun array. A detailed description of L-DEO's modeling for marine seismic source arrays for species mitigation is provided in Appendix A of NSF's EA. These are the nominal source levels applicable to downward propagation. The effective source levels for horizontal propagation are lower than those for downward propagation when the source consists of numerous airguns spaced apart from one another.

Appendix A of NSF's EA discusses the characteristics of the airgun pulses. NMFS refers the reviewers to the application and EA documents for additional information.

Predicted Sound Levels for the Airguns

Received sound levels have been modeled by L-DEO for a number of airgun

configurations, including two 45 in³ GI airguns, in relation to distance and direction from the airguns (see Figure 2 of the IHA application). The model does not allow for bottom interactions, and is most directly applicable to deep water. Based on the modeling, estimates of the maximum distances from the GI airguns where sound levels of 190, 180, and 160 dB re 1 μ Pa (rms) are predicted to be received in deep water are shown in Table 1 (see Table 1 of the IHA application).

Empirical data concerning the 190, 180, and 160 dB (rms) distances were acquired for various airgun arrays based on measurements during the acoustic verification studies conducted by L-DEO in the northern GOM in 2003 (Tolstoy et al., 2004) and 2007 to 2008 (Tolstoy et al., 2009). Results of the 36 airgun array are not relevant for the two GI airguns to be used in the proposed survey. The empirical data for the 6, 10, 12, and 20 airgun arrays indicate that, for deep water, the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy et al., 2004). Measurements were not made for the two GI airgun array in deep water, however, SIO proposes to use the EZ predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative given the empirical proposed GI airgun operations in deep water. Using the L-DEO model, Table 1 (below) shows the distances at which three rms sound levels are expected to be received from the two GI airgun array. The 180 and 190 dB re 1 μ Pa (rms) distances are the safety criteria for potential Level A harassment as specified by NMFS (2000) and are applicable to cetaceans and pinnipeds, respectively. If marine mammals are detected within or about to enter the appropriate EZ, the airguns will be shut-down immediately. Table 1 summarizes the predicted distances at which sound levels (160, 180, and 190 dB [rms]) are expected to be received from the two GI airgun array operating in deep water depths.

Table 1. Distances to which sound levels \geq 190, 180, and 160 dB re 1 μ Pa (rms) could be received in deep water during the proposed seismic survey in the south-eastern Pacific Ocean,

May, 2012. Distances are based on model results provided by L-DEO.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Radii Distances (m)		
			190 dB	180 dB	160 dB
Two GI airguns (45 in ³)	2	Deep (> 1,000)	10	40	350

MBES

The Melville will operate a Kongsberg EM 122 MBES operates at 10.5 to 13 (usually 12) kHz and is hull-mounted on the Melville. The transmitting beamwidth is 1° fore-aft and 150° athwartship. The maximum source level is 242 dB re 1 μPam (rms). Each “ping” consists of eight (in water >1,000 m deep) or four (<1,000 m) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore-aft. Continuous-wave pulses increase from 2 to 15 milliseconds (ms) long in water depths up to 2,600 m (8,530.2 ft), and FM chirp pulses up to 100 ms long are used in water greater than 2,600 m. The successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between the pulses for successive sectors.

SBP

The Melville will also operate an Knudsen Engineering Model 3260 SBP continuously throughout the cruise simultaneously with the MBES to map and provide information about the sedimentary features that occur below the sea floor. The SBP is capable of reaching depths of 10,000 m (32,808.4 ft). The beam is transmitted as a 27° cone, which is directed downward by a 3.5 kHz transducer array mounted on the hull of the Melville. The nominal power output is 10 kilowatts (kW) or 222 dB re 1 μPam. The ping duration is up to 64 ms, and ping interval is 1 s. A common mode of operation is to broadcast five pings at 1 s intervals followed by a 5 s pause. The 12 kHz section is seldom used in survey mode on the Melville because of overlap with the

operating frequency of the Kongsberg EM 122 MBES.

NMFS expects that acoustic stimuli resulting from the proposed operation of the two GI airgun array has the potential to harass marine mammals, incidental to the conduct of the proposed seismic survey. NMFS expects these disturbances to be temporary and result, at worst, in a temporary modification in behavior and/or low-level physiological effects (Level B harassment) of small numbers of certain species of marine mammals. NMFS does not expect that the movement of the Melville, during the conduct of the seismic survey, has the potential to harass marine mammals because of the relatively slow operation speed of the vessel (approximately 8 to 12 km/hr [4 to 6 kt] and 15-18.5 km/hr [8 to 10 kt]) during seismic acquisition.

OBS Description and Deployment

Approximately 10 broadband OBSs will be deployed and recovered by the Melville during the proposed survey. L-DEO OBS08 model broadband OBSs will be used during the cruise. This type of OBS has a height of approximately 122 centimeters (cm) (48 inches [in]) and width and depth of 76.2 x 106.7 cm (30 x 42 in). The anchor is made of two steel cylinders approximately 15 cm (5.9 in) in diameter and 46 cm (18.1 in) in length. Each cylinder weighs approximately 75 pounds (lbs) (34 kilograms [kg]) in the air. OBSs will remain on the seafloor to continue to collect data for approximately one year. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9 to 11 kilohertz (kHz), and a response is received at a frequency of 9 to 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 the Proposed Dates, Duration, and Specified Geographic Region

The Melville is expected to depart and return to Valparaiso, Chile. The cruise is scheduled to occur for approximately five to 11 days from May 4 to 18, 2012. Some minor

deviation from this schedule is possible, depending on logistics and weather. The survey will occur in the area approximately 34° to 35° South, approximately 72° to 74° West (see Figure 1 of the IHA application). Water depths in the survey area generally range from approximately 1,000 to 5,300 m (3,280.8 to 17,388.5 ft). The seismic survey will be conducted in the EEZ of Chile, approximately 50 km (27 nmi) off the coast of.

Description of the Marine Mammals in the Area of the Proposed Specified Activity

Thirty-two marine mammal species could occur in the south-eastern Pacific Ocean survey area. Twenty-eight cetacean species (22 odontocetes and 6 mysticetes) and four pinniped species could occur in the south-eastern Pacific Ocean study area. Several of these species are listed as endangered under the U.S. Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 *et seq.*), including the humpback (*Megaptera novaeangliae*), sei (*Balaenoptera borealis*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), and sperm (*Physeter macrocephalus*) whale.

An additional 12 cetacean species, although present in the wider south-eastern Pacific Ocean, likely would not be found in the proposed seismic survey area because their ranges in the survey area are extralimital, or they are typically found in coastal water. Southern right whales (*Eubalaena australis*) are listed as endangered under the ESA. Sightings are seen on rare occasions off the coasts of Peru and Chile (Aguayo *et al.*, 1992; Santillan *et al.*, 2004), although females with calves have been observed between June and October. Given the size of this population, estimated at 50 individuals, in Chile and Peru (IWC, 2007; ICW, 2007b) and the rarity of the species in the survey area, it is unlikely that individuals from this subpopulation will be encountered. Pygmy right whales (*Caperea marginata*) are rarely seen at sea, but are known from stranding records off Chile (Cabrera *et al.*, 2005). Little is known about Arnoux's beaked whale (*Berardius arnuxii*) as they are rarely seen, but typically they are found between the

Antarctic continent and 34° South. The northernmost limit of their range overlaps with the survey area, but no records of their occurrence exist within the survey area. The spade toothed beaked whale (Mesoplodon traversii) and Shepherd's beaked whale (Tasmacetus shepherdii) are uncommon species, but individuals have been described from stranding records in the Juan Fernandez Archipelago in Chile (Reyes et al., 1996) approximately 700 km (378 nmi) west of the survey site. The ginkgo-toothed beaked whale (Mesoplodon ginkgodens), pygmy beaked whale (Mesoplodon peruvianus), and the long-beaked common dolphin (Delphinus capensis) are likely extralimital with distributions mostly north of the survey area. The Commerson's dolphin (Cephalorhynchus commersonii), hourglass dolphin (Lagenorhynchus cruciger), and southern bottlenose whale (Hyperoodon planifrons) are also extralimital in the survey area, but have a northernmost extent that is south of the survey area.

No cetacean distribution and abundance studies have been conducted in the proposed survey area. The closest distribution studies have been in the Eastern Tropical Pacific (ETP) and Patagonia, in southern Chile. Several other studies of marine mammal distribution and abundance have been conducted in the wider ETP. The most extensive regional distribution and abundance data come primarily from multi-year vessel surveys conducted by NMFS's Southwest Fisheries Science Center (SWFSC). The surveys were conducted during July to December in an area generally extending from 30° North to 18° South from the coastline to 153° West (Wade and Gerrodette, 1993; Ferguson and Barlow, 2001; Gerrodette et al., 2008; and Jackson et al., 2008).

The marine mammals that occur in the proposed survey area belong to three taxonomic groups: odontocetes (toothed whales and dolphins), mysticetes (baleen whales), and pinnipeds (seals, sea lions, and walrus). Cetaceans and pinnipeds are the subject of the IHA application to NMFS.

Table 2 (below) presents information on the abundance, distribution, population status, conservation status, and density of the marine mammals that may occur in the proposed survey area during May, 2012.

Table 2. The habitat, regional abundance, and conservation status of marine mammals that may occur in or near the proposed seismic survey area in the south-eastern Pacific Ocean. [See text and Tables 2 to 3 in SIO’s application for further details.]

Species	Habitat	Abundance	ESA ¹	MMPA ²	Density (#/1,000 km ²) ³
Mysticetes					
Humpback whale (<i>Megaptera novaeangliae</i>)	Mainly nearshore waters and banks	2,900 ⁶ (SE Pacific)	EN	D	0.8 ⁴
Minke whale (<i>Balaenoptera acutorostrata</i>)	Coastal	338,000 ⁷	NL	NC	0.8 ⁴
Bryde’s whale (<i>Balaenoptera edeni</i>)	Pelagic and coastal	130,008	NL	NC	0.96
Sei whale (<i>Balaenoptera borealis</i>)	Mostly pelagic	11,000 ⁸	EN	D	0.01 ⁵
Fin whale (<i>Balaenoptera physalus</i>)	Slope, mostly pelagic	15,178 ⁹	EN	D	0.01 ⁵
Blue whale (<i>Balaenoptera musculus</i>)	Pelagic and coastal	1,415 ¹⁰	EN	D	2.44
Odontocetes					
Sperm whale (<i>Physeter macrocephalus</i>)	Usually deep pelagic, steep topography	26,053 ¹¹	EN	D	3.95
Pygmy sperm whale (<i>Kogia breviceps</i>)	Deep waters off shelf	150,000 ¹²	NL	NC	0.03
Dwarf sperm whale (<i>Kogia sima</i>)	Deep waters off shelf	150,000 ¹²	NL	NC	0.03
Cuvier’s beaked whale (<i>Ziphius cavirostris</i>)	Slope and pelagic	20,000 ¹³	NL	NC	0.80
Blainville’s beaked whale (<i>Mesoplodon densirostris</i>)	Slope and pelagic	25,300 ¹⁴	NL	NC	0.80
Gray’s beaked whale (<i>Mesoplodon grayi</i>)	Slope and pelagic	NA	NL	NC	NA
Hector’s beaked whale (<i>Mesoplodon hectori</i>)	Slope and pelagic	NA	NL	NC	NA
Strap-toothed beaked whale	Slope and pelagic	NA	NL	NC	NA

<i>(Mesoplodon layardii)</i>					
Unidentified <u>Mesoplodon</u> spp.	Slope and pelagic	NA	NL	NC	0.36
Rough-toothed dolphin (<i>Steno bredanensis</i>)	Mainly pelagic	107,633	NL	NC	4.19
Bottlenose dolphin (<i>Tursiops truncatus</i>)	Coastal, shelf, pelagic	335,834	NL	NC D – Western North Atlantic coastal	17.06
Spinner dolphin (<i>Stenella longirostris</i>)	Coastal and pelagic	1,797,716	NL	NC	35.70
Striped dolphin (<i>Stenella coeruleoalba</i>)	Off continental shelf	964,362	NL	NC D - Eastern	67.80
Short-beaked common dolphin (<i>Delphinus delphis</i>)	Shelf, pelagic, high relief	3,127,203	NL	NC	110.90
Risso's dolphin (<i>Grampus griseus</i>)	Shelf, slope, seamounts	110,457	NL	NC	10.21
False killer whale (<i>Pseudorca crassidens</i>)	Pelagic	398,009	NL Proposed EN – insular Hawaiian	NC	0.39
Killer whale (<i>Orcinus orca</i>)	Widely distributed	8,500 ¹⁵	NL EN – Southern resident	NC D – Southern resident, AT1 transient	0.85
Long-finned pilot whale (<i>Globicephala melas</i>)	Shelf and pelagic	200,000 ¹⁶	NL	NC	11.88
Peale's dolphin (<i>Lagenorhynchus australis</i>)	Coastal and shelf	NA	NL	NC	0.8 ⁴
Dusky dolphin (<i>Lagenorhynchus obscurus</i>)	Shelf and slope	7,252 ¹⁷	NL	NC	37
Southern right whale dolphin (<i>Lissodelphis peronni</i>)	Pelagic	NA	NL	NC	0.01 ⁵
Chilean dolphin (<i>Cephalorhynchus eutropia</i>)	Coastal and shelf	< 10,000 ¹⁸	NL	NC	11.11
Burmeister's porpoise (<i>Phocoena spinipinnis</i>)	Coastal	NA	NL	NC	0.01 ⁵
Pinnipeds					
South American fur seal (<i>Otaria flavescens</i>)	Coastal and shelf	30,000 ¹⁹	NL	NC	NA

Juan Fernandez fur seal (<i>Arctocephalus philippii</i>)	Coastal and shelf	12,000 ²⁰	NL	NC	NA
South American sea lion (<i>Arctocephalus australis</i>)	Coastal and shelf	150,000 ²¹	NL	NC	NA
Southern elephant seal (<i>Mirounga leonina</i>)	Coastal and pelagic	650,000 ²²	NL	NC	NA

N.A. Not available or not assessed.

¹ U.S. Endangered Species Act: EN = Endangered, T = Threatened, NL = Not listed.

² U.S. Marine Mammal Protection Act: D = Depleted, NC = Not Classified.

³ Densities of other species (e.g., pinnipeds) presumably would be lower than the lowest density in Table 3 of the application.

⁴ Densities assigned an arbitrary density similar to densities reported for species that are uncommon in the survey area.

⁵ Densities assigned an arbitrarily low number for rare species with unconfirmed sightings in the survey area.

⁶ Southeast Pacific (Felix *et al.*, 2005)

⁷ Estimated from Antarctic and common minke whales in South Pacific (Reilly, 2011).

⁸ Based on 2007 projection for southern hemisphere (IWC, 1996).

⁹ Based on 2007 projection for southern hemisphere (Reilly, 2011).

¹⁰ ETP (Wade and Gerrodette, 1993) excluded nursing area south of study area estimated at approximately 267 animals.

¹¹ Eastern temperate North Pacific (Whitehead, 2002).

¹² This abundance estimate is for *Kogia sima* and *Kogia breviceps* in ETP (Ferguson and Barlow, 2001).

¹³ ETP (Wade and Gerrodette, 1993).

¹⁴ This estimate includes all species of the genus *Mesoplodon* in the ETP (Ferguson and Barlow, 2001).

¹⁵ ETP (Ford, 2002).

¹⁶ Southern hemisphere population (Waring *et al.*, 1997).

¹⁷ Patagonian coast population (Dans *et al.*, 1997).

¹⁸ South-Eastern Pacific (Reeves *et al.*, 2008).

¹⁹ Chile (Arias, Shreiber, and Rivas, 1998).

²⁰ Juan Fernandez Archipelago population (Aurioles and Trillmich, 2008).

²¹ Peru and Chile (Campagna, 2008a).

²² Southern hemisphere (Campagna, 2009).

Refer to Section III and IV of SIO's application for detailed information regarding the abundance and distribution, population status, and life history and behavior of these species and their occurrence in the proposed project area. The application also presents how SIO calculated the estimated densities for the marine mammals in the proposed survey area. NMFS has reviewed these data and determined them to be the best available scientific information for the purposes of the proposed IHA.

Potential Effects on Marine Mammals

Acoustic stimuli generated by the operation of the airguns, which introduce sound into the marine environment, may have the potential to cause Level B harassment of marine mammals in the proposed survey area. The effects of sounds from airgun operations might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al., 1995; Gordon et al., 2004; Nowacek et al., 2007; Southall et al., 2007).

Permanent hearing impairment, in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al., 2007). Although the possibility cannot be entirely excluded, it is unlikely that the proposed project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. Based on the available data and studies described here, some behavioral disturbance is expected, but NMFS expects the disturbance to be localized and short-term.

Tolerance to Sound

Studies on marine mammals' tolerance to sound in the natural environment are relatively rare. Richardson et al. (1995) defines tolerance as the occurrence of marine mammals in areas

where they are exposed to human activities or man-made noise. In many cases, tolerance develops by the animal habituating to the stimulus (i.e., the gradual waning of responses to a repeated or ongoing stimulus) (Richardson, et al., 1995; Thorpe, 1963), but because of ecological or physiological requirements, many marine animals may need to remain in areas where they are exposed to chronic stimuli (Richardson, et al., 1995).

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kms. Several studies have shown that marine mammals at distances more than a few kms from operating seismic vessels often show no apparent response (see Appendix A[5] in the EA). That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales and toothed whales have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of both types have shown no over reactions. The relative responsiveness of baleen and toothed whales are quite variable.

Masking of Natural Sounds

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark et al., 2009). Introduced underwater sound may, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al., 1995).

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific

data on this. Because of the intermittent nature and low duty cycle of seismic airgun pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in some situations, reverberation occurs for much or the entire interval between pulses (e.g., Simard et al., 2005; Clark and Gagnon, 2006) which could mask calls. Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls can usually be heard between the seismic pulses (e.g., Richardson et al., 1986; McDonald et al., 1995; Greene et al., 1999; Nieuwirth et al., 2004; Smultea et al., 2004; Holst et al., 2005a,b, 2006; and Dunn and Hernandez, 2009). However, Clark and Gagnon (2006) reported that fin whales in the northeast Pacific Ocean went silent for an extended period starting soon after the onset of a seismic survey in the area. Similarly, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al., 1994). However, more recent studies found that they continued calling in the presence of seismic pulses (Madsen et al., 2002; Tyack et al., 2003; Smultea et al., 2004; Holst et al., 2006; and Jochens et al., 2008). Dolphins and porpoises commonly are heard calling while airguns are operating (e.g., Gordon et al., 2004; Smultea et al., 2004; Holst et al., 2005a, b; and Potter et al., 2007). 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, NMFS expects the masking effects of seismic pulses to be minor, given the normally intermittent nature of seismic pulses. Refer to Appendix A(4) of NSF's EA for a more detailed discussion of masking effects on marine mammals.

Behavioral Disturbance

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. 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). 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. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder, 2007; Weilgart, 2007). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based primarily on behavioral observations of a few species. Scientists have conducted detailed studies on humpback, gray, bowhead (Balaena mysticetus), and sperm whales, and on ringed seals (Phoca hispida). Less detailed data are available for some other species of baleen whales, small toothed whales, and sea otters, 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 (reviewed in Richardson et al., 1995). Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kms, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, as reviewed in Appendix A(5) of NSF's EA, 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 (Richardson, et al., 1995). They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have shown that seismic pulses with received levels of 160 to 170 dB re 1 μ Pa (rms) seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed (Malme et al., 1986, 1988; Richardson et al., 1995). In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4.5 to 14.5 km (2.4 to 7.8 nmi) from the source. A substantial proportion of the baleen whales within those distances may show avoidance or other strong behavioral reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and studies summarized in Appendix A(5) of NSF's EA have shown that some species of baleen whales, notably bowhead and humpback whales, at times, show strong avoidance at received levels lower than 160 to 170 dB re 1 μ Pa (rms).

McCauley et al. (1998, 2000a) studied the responses of humpback whales off western Australia to a full-scale seismic survey with a 16 airgun array (2,678 in³) and to a single airgun (20 in³) with source level of 227 dB re 1 μ Pa (p-p). In the 1998 study, they documented that avoidance reactions began at five to eight km (2.7 to 4.3 nmi) from the array, and that those reactions kept most pods approximately three to four km from the operating seismic boat. In the 2000 study, they noted localized displacement during migration of four to five km by traveling pods and seven to 12 km (6.5 nmi) by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single airgun were smaller but consistent with the results from the

full array in terms of the received sound levels. The mean received level for initial avoidance of an approaching airgun was 140 dB re 1 μ Pa (rms) for humpback pods containing females, and at the mean closest point of approach distance the received level was 143 dB re 1 μ Pa (rms). The initial avoidance response generally occurred at distances of five to eight km from the airgun array and two km from the single airgun. However, some individual humpback whales, especially males, approached within distances of 100 to 400 m (328 to 1,312 ft), where the maximum received level was 179 dB re 1 μ Pa (rms).

Data collected by observers during several seismic surveys in the Northwest Atlantic showed that sighting rates of humpback whales were significantly greater during non-seismic periods compared with periods when a full array was operating (Moulton and Holst, 2010). In addition, 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).

Humpback whales on their summer feeding grounds in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100 in³) airgun (Malme *et al.*, 1985). Some humpbacks seemed “startled” at received levels of 150 to 169 dB re 1 μ Pa. Malme *et al.* (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 dB re 1 μ Pa (rms). However, Moulton and Holst (2010) reported that humpback whales monitored during seismic surveys in the Northwest Atlantic had lower sighting rates and were most often seen swimming away from the vessel during seismic periods compared with periods when airguns were silent.

Studies have suggested that south Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel *et al.*, 2004). The evidence for this was circumstantial and subject to alternative explanations (IAGC, 2004). Also, the evidence

was not consistent with subsequent results from the same area of Brazil (Parente *et al.*, 2006), or with direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was no observable direct correlation between strandings and seismic surveys (IWC, 2007:236).

There are no data on reactions of right whales to seismic surveys, but results from the closely-related bowhead whale show that their responsiveness can be quite variable depending on their activity (migrating versus 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 to 30 km (10.8 to 16.2 nmi) from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 μ Pa (Miller *et al.*, 1999; Richardson *et al.*, 1999; see Appendix A[5] of NSF's EA). However, more recent research on bowhead whales (Miller *et al.*, 2005; Harris *et al.*, 2007) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. Nonetheless, subtle but statistically significant changes in surfacing–respiration–dive cycles were evident upon statistical analysis (Richardson *et al.*, 1986). In the summer, bowheads typically begin to show avoidance reactions at received levels of about 152 to 178 dB re 1 μ Pa (Richardson *et al.*, 1986, 1995; Ljungblad *et al.*, 1988; Miller *et al.*, 2005).

Reactions of migrating and feeding (but not wintering) gray whales to seismic surveys have been studied. Malme *et al.* (1986, 1988) studied the responses of feeding eastern Pacific gray whales to pulses from a single 100 in³ airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 μ Pa on an (approximate) rms basis, and that 10 percent of feeding whales interrupted feeding at received levels of 163 dB

re 1 μ Pa (rms). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al., 1984; Malme and Miles, 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (Wursig et al., 1999; Gailey et al., 2007; Johnson et al., 2007; Yazvenko et al., 2007a, b), along with data on gray whales off British Columbia (Bain and Williams, 2006).

Various species of Balaenoptera (blue, sei, fin, and minke whales) have occasionally been seen in areas ensounded by airgun pulses (Stone, 2003; MacLean and Haley, 2004; Stone and Tasker, 2006), and calls from blue and fin whales have been localized in areas with airgun operations (e.g., McDonald et al., 1995; Dunn and Hernandez, 2009; Castellote et al., 2010). Sightings by observers on seismic vessels off the United Kingdom from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were shooting vs. silent (Stone, 2003; Stone and Tasker, 2006). However, these whales tended to exhibit localized avoidance, remaining significantly further (on average) from the airgun array during seismic operations compared with non-seismic periods (Stone and Tasker, 2006). Castellote et al. (2010) reported that singing fin whales in the Mediterranean moved away from an operating airgun array.

Ship-based monitoring studies of baleen whales (including blue, fin, sei, minke, and humpback whales) in the Northwest Atlantic found that overall, this group had lower sighting rates during seismic vs. non-seismic periods (Moulton and Holst, 2010). Baleen whales as a group were also seen significantly farther from the vessel during seismic compared with non-seismic periods, and they were more often seen to be swimming away from the operating seismic vessel (Moulton and Holst, 2010). Blue and minke whales were initially sighted significantly farther from the vessel during seismic operations compared to non-seismic periods; the same

trend was observed for fin whales (Moulton and Holst, 2010). Minke whales were most often observed to be swimming away from the vessel when seismic operations were underway (Moulton and Holst, 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme *et al.*, 1984; Richardson *et al.*, 1995; Allen and Angliss, 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year (Johnson *et al.*, 2007). Similarly, 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 (Richardson *et al.*, 1987; Allen and Angliss, 2010).

Toothed Whales - Little systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above and (in more detail) in Appendix A of NSF's EA have been reported for toothed whales. However, there are recent systematic studies on sperm whales (e.g., Gordon *et al.*, 2006; Madsen *et al.*, 2006; Winsor and Mate, 2006; Jochens *et al.*, 2008; Miller *et al.*, 2009). There is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone, 2003; Smultea *et al.*, 2004; Moulton and Miller, 2005; Bain and Williams, 2006; Holst *et al.*, 2006; Stone and Tasker, 2006; Potter *et al.*,

2007; Hauser et al., 2008; Holst and Smultea, 2008; Weir, 2008; Barkaszi et al., 2009; Richardson et al., 2009; Moulton and Holst, 2010).

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., Goold, 1996a,b,c; Calambokidis and Osmeck, 1998; Stone, 2003; Moulton and Miller, 2005; Holst et al., 2006; Stone and Tasker, 2006; Weir, 2008; Richardson et al., 2009; Barkaszi et al., 2009; Moulton and Holst, 2010). Some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing (e.g., Moulton and Miller, 2005). Nonetheless, small toothed whales more often tend to head away, or to maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Stone and Tasker, 2006; Weir, 2008; Barry et al., 2010; Moulton and Holst, 2010). In most cases, the avoidance radii for delphinids appear to be small, on the order of one km or less, and some individuals show no apparent avoidance. The beluga whale (*Delphinapterus leucas*) is a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys conducted in the southeastern Beaufort Sea during summer found that sighting rates of beluga whales were significantly lower at distances 10 to 20 km compared with 20 to 30 km from an operating airgun array, and observers on seismic boats in that area rarely see belugas (Miller et al., 2005; Harris et al., 2007).

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 (Finneran et al., 2000, 2002, 2005). However, the animals tolerated high received levels of sound before exhibiting aversive behaviors.

Results for porpoises depend on species. The limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than do Dall's porpoises (Stone, 2003; MacLean and Koski, 2005; Bain and Williams, 2006; Stone and Tasker, 2006). Dall's porpoises seem relatively tolerant of airgun operations (MacLean and Koski, 2005; Bain and Williams, 2006), although they too have been observed to avoid large arrays of operating airguns (Calambokidis and Osmek, 1998; Bain and Williams, 2006). This apparent difference in responsiveness of these two porpoise species is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson et al., 1995; Southall et al., 2007).

Most studies of sperm whales exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses (e.g., Stone, 2003; Moulton et al., 2005, 2006a; Stone and Tasker, 2006; Weir, 2008). In most cases the whales do not show strong avoidance, and they continue to call (see Appendix A of NSF's EA for review). However, controlled exposure experiments in the GOM indicate that foraging behavior was altered upon exposure to airgun sound (Jochens et al., 2008; Miller et al., 2009; Tyack, 2009).

There are almost no specific data on the behavioral reactions of beaked whales to seismic surveys. However, some northern bottlenose whales (Hyperoodon ampullatus) remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (Gosselin and Lawson, 2004; Laurinolli and Cochrane, 2005; Simard et al., 2005). Most beaked whales tend to avoid approaching vessels of other types (e.g., Wursig et al., 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya, 1986), although it is uncertain how much longer such dives may be as compared to dives by undisturbed beaked whales, which also are often quite long (Baird et al., 2006; Tyack et al., 2006). Based on a single observation, Aguilar-Soto et al. (2006) suggested that foraging

efficiency of Cuvier's beaked whales may be reduced by close approach of vessels. In any event, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly. In fact, Moulton and Holst (2010) reported 15 sightings of beaked whales during seismic studies in the Northwest Atlantic; seven of those sightings were made at times when at least one airgun was operating. There was little evidence to indicate that beaked whale behavior was affected by airgun operations; sighting rates and distances were similar during seismic and non-seismic periods (Moulton and Holst, 2010).

There are increasing indications that some beaked whales tend to strand when naval exercises involving mid-frequency sonar operation are ongoing nearby (e.g., Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; NOAA and USN, 2001; Jepson *et al.*, 2003; Hildebrand, 2005; Barlow and Gisiner, 2006; see also the Stranding and Mortality section in this document). These strandings are apparently a disturbance response, although auditory or other injuries or other physiological effects may also be involved. Whether beaked whales would ever react similarly to seismic surveys is unknown. Seismic survey sounds are quite different from those of the sonar in operation during the above-cited incidents.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids and Dall's porpoises, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes, belugas, and harbor porpoises (Appendix A of NSF's EA).

Pinnipeds – Pinnipeds are not likely to show a strong avoidance reaction to the 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, see Appendix A(5) of NSF's EA. In the Beaufort Sea, some ringed seals avoided an area of 100 m to (at most) a few hundred

meters around seismic vessels, but many seals remained within 100 to 200 m (328 to 656 ft) of the trackline as the operating airgun array passed by (e.g., Harris et al., 2001; Moulton and Lawson, 2002; Miller et al., 2005). Ringed seal sightings averaged somewhat farther away from the seismic vessel when the airguns were operating than when they were not, but the difference was small (Moulton and Lawson, 2002). Similarly, in Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when airguns were operating (Calambokidis and Osmeck, 1998). Previous telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al., 1998).

Hearing Impairment and Other Physical Effects

Exposure to high intensity sound for a sufficient duration may result in auditory effects such as a noise-induced threshold shift - an increase in the auditory threshold after exposure to noise (Finneran, Carder, Schlundt, and Ridgway, 2005). Factors that influence the amount of threshold shift include the amplitude, duration, frequency content, temporal pattern, and energy distribution of noise exposure. The magnitude of hearing threshold shift normally decreases over time following cessation of the noise exposure. The amount of threshold shift just after exposure is called the initial threshold shift. If the threshold shift eventually returns to zero (i.e., the threshold returns to the pre-exposure value), it is called temporary threshold shift (TTS) (Southall et al., 2007).

Researchers have studied TTS in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al., 2007). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., permanent threshold shift (PTS), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Temporary Threshold Shift - TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound. Available data on TTS in marine mammals are summarized in Southall *et al.* (2007). Table 1 (above) presents the distances from the Melville's airguns at which the received energy level (per pulse, flat-weighted) would be expected to be greater than or equal to 190 dB re 1 μ Pa (rms).

Researchers have derived TTS information for odontocetes from studies on the bottlenose dolphin and beluga. For the one harbor porpoise tested, the received level of airgun sound that elicited onset of TTS was lower (Lucke *et al.*, 2009). If these results from a single animal are representative, it is inappropriate to assume that onset of TTS occurs at similar received levels in all odontocetes (*cf.* Southall *et al.*, 2007). Some cetaceans apparently can incur TTS at considerably lower sound exposures than are necessary to elicit TTS in the beluga or bottlenose dolphin.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are assumed to be lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than

are those of odontocetes at their best frequencies (Clark and Ellison, 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales (Southall *et al.*, 2007). For this proposed study, SIO expects no cases of TTS given the low abundance of baleen whales in the proposed survey area at the time of the proposed survey, and the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for TTS to occur.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from more prolonged (non-pulse) exposures suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak *et al.*, 1999, 2005; Ketten *et al.*, 2001). The TTS threshold for pulsed sounds has been indirectly estimated as being an SEL of approximately 171 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$ (Southall *et al.*, 2007) which would be equivalent to a single pulse with a received level of approximately 181 to 186 dB re 1 μPa (rms), or a series of pulses for which the highest rms values are a few dB lower. Corresponding values for California sea lions and northern elephant seals are likely to be higher (Kastak *et al.*, 2005).

To avoid the potential for injury, NMFS (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa (rms) and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 190 dB re 1 μPa (rms). NMFS believes that to avoid the potential for permanent physiological damage (Level A harassment), cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa (rms) and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 190 dB re 1 μPa (rms). The 180 dB and 190 dB

levels are the shutdown criterion applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000); these levels were used to establish the EZs. NMFS also assumes that marine mammals exposed to levels exceeding 160 dB re 1 μ Pa (rms) may experience Level B harassment.

Permanent Threshold Shift - When PTS occurs, there is physical damage to the sound receptors in the ear. In severe cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985). 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 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. 372ff; Gedamke *et al.*, 2008). 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.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several dBs above that inducing mild TTS if the animal were exposed to strong sound pulses with rapid rise time - see Appendix A(6) of SIO's EA. Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably greater than six dB (Southall *et al.*, 2007).

Given the higher level of sound necessary to cause PTS as compared with TTS, it is

considerably less likely that PTS would occur. Baleen whales generally avoid the immediate area around operating seismic vessels, as do some other marine mammals.

Stranding and Mortality - Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al., 1993; Ketten, 1995). However, explosives are no longer used for marine waters for commercial seismic surveys or (with rare exceptions) for seismic research; they have been replaced entirely by airguns or related non-explosive pulse generators. Airgun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of strandings of beaked whales with naval exercises involving mid-frequency active sonar and, in one case, an L-DEO seismic survey (Malakoff, 2002; Cox et al., 2006), has raised the possibility that beaked whales exposed to strong “pulsed” sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (e.g., Hildebrand, 2005; Southall et al., 2007). Appendix A(6) of SIO’s EA provides additional details.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include:

- (1) Swimming in avoidance of a sound into shallow water;
- (2) A change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage or other forms of trauma;
- (3) A physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and
- (4) Tissue damage directly from sound exposure, such as through acoustically-mediated

bubble formation and growth or acoustic resonance of tissues. Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are indications that gas-bubble disease (analogous to “the bends”), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. However, the evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox et al., 2006; Southall et al., 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to airgun pulses. Sounds produced by airgun arrays are broadband impulses with most of the energy below one kHz. Typical military mid-frequency sonar emits non-impulse sounds at frequencies of two to 10 kHz, generally with a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson et al., 2003; Fernández et al., 2004, 2005; Hildebrand 2005; Cox et al., 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity “pulsed” sound.

There is no conclusive evidence of cetacean strandings or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys

and strandings. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September, 2002, there was a stranding of two Cuvier's beaked whales (Ziphius cavirostris) in the Gulf of California, Mexico, when the L-DEO vessel R/V Maurice Ewing was operating a 20 airgun (8,490 in³) array in the general area. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002). Nonetheless, the Gulf of California incident plus the beaked whale strandings near naval exercises involving use of mid-frequency sonar suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales until more is known about effects of seismic surveys on those species (Hildebrand, 2005). No injuries of beaked whales are anticipated during the proposed study because of:

(1) The high likelihood that any beaked whales nearby would avoid the approaching vessel before being exposed to high sound levels, and

(2) Differences between the sound sources operated by SIO and those involved in the naval exercises associated with strandings.

Non-auditory Physiological Effects - Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al., 2006; Southall et al., 2007). Studies examining such effects are limited. However, resonance effects (Gentry, 2002) and direct noise-induced bubble formations (Crum et al., 2005) are implausible in the case of exposure to an impulsive broadband source like an airgun array. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of the bends, as speculated to occur in beaked whales exposed to

sonar. However, there is no specific evidence of this upon exposure to airgun pulses.

In general, very little is known about the potential for seismic survey sounds (or other types of strong underwater sounds) to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall *et al.*, 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales and some odontocetes, are especially unlikely to incur non-auditory physical effects.

Potential Effects of Other Acoustic Devices

MBES

SIO will operate the Kongsberg EM 122 MBES from the source vessel during the planned study. Sounds from the MBES are very short pulses, occurring for two to 15 ms once every five to 20 s, depending on water depth. Most of the energy in the sound pulses emitted by this MBES is at frequencies near 12 kHz, and the maximum source level is 242 dB re 1 μ Pam (rms). The beam is narrow (1 to 2°) in fore-aft extent and wide (150°) in the cross-track extent. Each ping consists of eight (in water greater than 1,000 m deep) or four (in water less than 1,000 m deep) successive fan-shaped transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only one or two of the segments. Also, marine mammals that encounter the Kongsberg EM 122 are unlikely to be subjected to repeated pulses because of the narrow fore-aft width of the beam and will receive only limited amounts of pulse energy because of the short pulses. Animals close to the ship

(where the beam is narrowest) are especially unlikely to be ensonified for more than two to 15 ms pulse (or two pings if in the overlap area). Similarly, Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when an MBES emits a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans: (1) generally have longer pulse duration than the Kongsberg EM 122; and (2) are often directed close to horizontally versus more downward for the MBES. The area of possible influence of the MBES is much smaller—a narrow band below the source vessel. Also, the duration of exposure for a given marine mammal can be much longer for naval sonar. During SIO's operations, the individual pulses will be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes by. Possible effects of an MBES on marine mammals are outlined below.

Masking - Marine mammal communications will not be masked appreciably by the MBES signals given the low duty cycle of the echosounder and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the MBES signals (12 kHz) do not overlap with the predominant frequencies in the calls, which would avoid any significant masking.

Behavioral Responses - Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins et al., 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon, 1999), and the previously-

mentioned beachings by beaked whales. During exposure to a 21 to 25 kHz “whale-finding” sonar with a source level of 215 dB re 1 μ Pa, gray whales reacted by orienting slightly away from the source and being deflected from their course by approximately 200 m (Frankel, 2005). When a 38 kHz echosounder and a 150 kHz acoustic Doppler current profiler were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis, 2005).

Captive bottlenose dolphins and a beluga whale exhibited changes in behavior when exposed to 1 s tonal signals at frequencies similar to those that will be emitted by the MBES used by SIO, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt *et al.*, 2000; Finneran *et al.*, 2002; Finneran and Schlundt, 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in duration as compared with those from an MBES.

Very few data are available on the reactions of pinnipeds to echosounder sounds at frequencies similar to those used during seismic operations. Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. Because of the likely brevity of exposure to the MBES sounds, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequences to the animals.

Hearing Impairment and Other Physical Effects - Given recent stranding events that have

been associated with the operation of naval sonar, there is concern that mid-frequency sonar sounds can cause serious impacts to marine mammals (see above). However, the MBES proposed for use by SIO is quite different than sonar used for Navy operations. Pulse duration of the MBES is very short relative to the naval sonar. 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; Navy sonar often uses near-horizontally-directed sound. Those factors would all reduce the sound energy received from the MBES rather drastically relative to that from naval sonar.

NMFS believes that the brief exposure of marine mammals to one pulse, or small numbers of signals, from the MBES is not likely to result in the harassment of marine mammals.

SBP

SIO will also operate a SBP from the source vessel during the proposed survey. Sounds from the SBP are very short pulses, occurring for up to 64 ms once every s. Most of the energy in the sound pulses emitted by the SBP is at 3.5 kHz, and the beam is directed downward. The SBP on the Melville has a maximum source level of 222 dB re 1 μ Pam (rms). Kremser *et al.* (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a pulse is small - even for an SBP more powerful than that on the Melville - if the animal was in the area, it would have to pass the transducer at close range in order to be subjected to sound levels that could cause TTS.

Masking - Marine mammal communications will not be masked appreciably by the SBP signals given the directionality of the signal and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of most baleen whales, the SBP signals do not overlap with the predominant frequencies in the calls, which would avoid significant

masking.

Behavioral Responses - Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the SBP are likely to be similar to those for other pulsed sources if received at the same levels. However, the pulsed signals from the SBP are considerably weaker than those from the MBES. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

Hearing Impairment and Other Physical Effects - It is unlikely that the SBP produces pulse levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source. The SBP is usually operated simultaneously with other higher-power acoustic sources, including airguns. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the less intense sounds from the SBP.

Acoustic Release Signals

The acoustic release transponder used to communicate with the OBSs uses frequencies nine to 13 kHz. These signals will be used very intermittently. It is unlikely that the acoustic release signals would have a significant effect on marine mammals through masking, disturbance, or hearing impairment. Any effects likely would be negligible given the brief exposure at presumable low levels.

The potential effects to marine mammals described in this section of the document do not take into consideration the proposed monitoring and mitigation measures described later in this document (see the Proposed Mitigation and Proposed Monitoring and Reporting sections) which, as noted are designed to effect the least practicable adverse impact on affected marine mammal

species and stocks.

Anticipated Effects on Marine Mammal Habitat

The proposed seismic survey will not result in any permanent impact on habitats used by the marine mammals in the proposed survey area, including the food sources they use (i.e. fish and invertebrates), and there will be no physical damage to any habitat. While it is anticipated that the specified activity may result in marine mammals avoiding certain areas due to temporary ensonification, this impact to habitat is temporary and reversible and was considered in further detail earlier in this document, as behavioral modification. The main impact associated with the proposed activity will be temporarily elevated noise levels and the associated direct effects on marine mammals, previously discussed in this notice.

Anticipated Effects on Fish

One reason for the adoption of airguns as the standard energy source for marine seismic surveys is that, unlike explosives, they have not been associated with large-scale fish kills. However, existing information on the impacts of seismic surveys on marine fish populations is limited (see Appendix D of NSF's EA). There are three types of potential effects of exposure to seismic surveys: (1) pathological, (2) physiological, and (3) behavioral. Pathological effects involve lethal and temporary or permanent sub-lethal injury. Physiological effects involve temporary and permanent primary and secondary stress responses, such as changes in levels of enzymes and proteins. Behavioral effects refer to temporary and (if they occur) permanent changes in exhibited behavior (e.g., startle and avoidance behavior). The three categories are interrelated in complex ways. For example, it is possible that certain physiological and behavioral changes could potentially lead to an ultimate pathological effect on individuals (i.e., mortality).

The specific received sound levels at which permanent adverse effects to fish potentially could occur are little studied and largely unknown. Furthermore, the available information on the impacts of seismic surveys on marine fish is from studies of individuals or portions of a population; there have been no studies at the population scale. The studies of individual fish have often been on caged fish that were exposed to airgun pulses in situations not representative of an actual seismic survey. Thus, available information provides limited insight on possible real-world effects at the ocean or population scale. This makes drawing conclusions about impacts on fish problematic because ultimately, the most important aspect of potential impacts relates to how exposure to seismic survey sound affects marine fish populations and their viability, including their availability to fisheries.

Hastings and Popper (2005), Popper (2009), and Popper and Hastings (2009a,b) provided recent critical reviews of the known effects of sound on fish. The following sections provide a general synopsis of the available information on the effects of exposure to seismic and other anthropogenic sound as relevant to fish. The information comprises results from scientific studies of varying degrees of rigor plus some anecdotal information. Some of the data sources may have serious shortcomings in methods, analysis, interpretation, and reproducibility that must be considered when interpreting their results (see Hastings and Popper, 2005). Potential adverse effects of the program's sound sources on marine fish are noted.

Pathological Effects – The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capability of the species in question (see Appendix D of NSF's EA). For a given sound to result in hearing loss, the sound must exceed, by some substantial amount, the hearing threshold of the fish for that sound (Popper, 2005). The consequences of temporary or permanent hearing loss in

individual fish on a fish population are unknown; however, they likely depend on the number of individuals affected and whether critical behaviors involving sound (e.g., predator avoidance, prey capture, orientation and navigation, reproduction, etc.) are adversely affected.

Little is known about the mechanisms and characteristics of damage to fish that may be inflicted by exposure to seismic survey sounds. Few data have been presented in the peer-reviewed scientific literature. As far as SIO and NMFS know, there are only two papers with proper experimental methods, controls, and careful pathological investigation implicating sounds produced by actual seismic survey airguns in causing adverse anatomical effects. One such study indicated anatomical damage, and the second indicated TTS in fish hearing. The anatomical case is McCauley *et al.* (2003), who found that exposure to airgun sound caused observable anatomical damage to the auditory maculae of pink snapper (*Pagrus auratus*). This damage in the ears had not been repaired in fish sacrificed and examined almost two months after exposure. On the other hand, Popper *et al.* (2005) documented only TTS (as determined by auditory brainstem response) in two of three fish species from the Mackenzie River Delta. This study found that broad whitefish (*Coregonus nasus*) exposed to five airgun shots were not significantly different from those of controls. During both studies, the repetitive exposure to sound was greater than would have occurred during a typical seismic survey. However, the substantial low-frequency energy produced by the airguns [less than 400 Hz in the study by McCauley *et al.* (2003) and less than approximately 200 Hz in Popper *et al.* (2005)] likely did not propagate to the fish because the water in the study areas was very shallow (approximately nine m in the former case and less than two m in the latter). Water depth sets a lower limit on the lowest sound frequency that will propagate (the “cutoff frequency”) at about one-quarter wavelength (Urlick, 1983; Rogers and Cox, 1988).

Wardle et al. (2001) suggested that in water, acute injury and death of organisms exposed to seismic energy depends primarily on two features of the sound source: (1) the received peak pressure and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. According to Buchanan et al. (2004), for the types of seismic airguns and arrays involved with the proposed program, the pathological (mortality) zone for fish would be expected to be within a few meters of the seismic source. Numerous other studies provide examples of no fish mortality upon exposure to seismic sources (Falk and Lawrence, 1973; Holliday et al., 1987; La Bella et al., 1996; Santulli et al., 1999; McCauley et al., 2000a,b, 2003; Bjarti, 2002; Thomsen, 2002; Hassel et al., 2003; Popper et al., 2005; Boeger et al., 2006).

Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Booman et al., 1996; Dalen et al., 1996). Some of the reports claimed seismic effects from treatments quite different from actual seismic survey sounds or even reasonable surrogates. However, Payne et al. (2009) reported no statistical differences in mortality/morbidity between control and exposed groups of capelin eggs or monkfish larvae. Saetre and Ona (1996) applied a 'worst-case scenario' mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Physiological Effects - Physiological effects refer to cellular and/or biochemical responses of fish to acoustic stress. Such stress potentially could affect fish populations by

increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary in all studies done to date (Sverdrup *et al.*, 1994; Santulli *et al.*, 1999; McCauley *et al.*, 2000a,b). The periods necessary for the biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus (see Appendix D of NSF's EA).

Behavioral Effects - Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior have been conducted on both uncaged and caged individuals (e.g., Chapman and Hawkins, 1969; Pearson *et al.*, 1992; Santulli *et al.*, 1999; Wardle *et al.*, 2001; Hassel *et al.*, 2003). Typically, in these studies fish exhibited a sharp “startle” response at the onset of a sound followed by habituation and a return to normal behavior after the sound ceased.

There is general concern about potential adverse effects of seismic operations on fisheries, namely a potential reduction in the “catchability” of fish involved in fisheries. Although reduced catch rates have been founded by other sources of disturbance (Dalen and Raknes, 1985; Dalen and Knutsen, 1986; Lokkeborg, 1991; Skalski *et al.*, 1992; Engas *et al.*, 1996). In other airgun experiments, there was no change in catch per unit effort of fish when airgun pulses were emitted, particularly in the immediate vicinity of the seismic survey (Pickett *et al.*, 1994; La Bella *et al.*, 1996). For some species, reductions in catch may have resulted from a change in behavior of the fish, e.g., a change in vertical or horizontal distribution, as reported in Slotte *et al.* (2004).

In general, any adverse effects on fish behavior or fisheries attributable to seismic testing may depend on the species in question and the nature of the fishery (season, duration, fishing

method). They may also depend on the age of the fish, its motivational state, its size, and numerous other factors that are difficult, if not impossible, to quantify at this point, given such limited data on effects of airguns on fish, particularly under realistic at-sea conditions.

Anticipated Effects on Invertebrates

The existing body of information on the impacts of seismic survey sound on marine invertebrates is very limited. However, there is some unpublished and very limited evidence of the potential for adverse effects on invertebrates, thereby justifying further discussion and analysis of this issue. The three types of potential effects of exposure to seismic surveys on marine invertebrates are pathological, physiological, and behavioral. Based on the physical structure of their sensory organs, marine invertebrates appear to be specialized to respond to particle displacement components of an impinging sound field and not to the pressure component (Popper *et al.*, 2001; see also Appendix E of NSF's EA).

The only information available on the impacts of seismic surveys on marine invertebrates involves studies of individuals; there have been no studies at the population scale. Thus, available information provides limited insight on possible real-world effects at the regional or ocean scale. The most important aspect of potential impacts concerns how exposure to seismic survey sound ultimately affects invertebrate populations and their viability, including availability to fisheries.

Literature reviews of the effects of seismic and other underwater sound on invertebrates were provided by Moriyasu *et al.* (2004) and Payne *et al.* (2008). The following sections provide a synopsis of available information on the effects of exposure to seismic survey sound on species of decapod crustaceans and cephalopods, the two taxonomic groups of invertebrates on which most such studies have been conducted. The available information is from studies with variable

degrees of scientific soundness and from anecdotal information. A more detailed review of the literature on the effects of seismic survey sound on invertebrates is provided in Appendix E of NSF's EA.

Pathological Effects – In water, lethal and sub-lethal injury to organisms exposed to seismic survey sound appears to depend on at least two features of the sound source: (1) the received peak pressure; and (2) the time required for the pressure to rise and decay. Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases. For the type of airgun array planned for the proposed program, the pathological (mortality) zone for crustaceans and cephalopods is expected to be within a few meters of the seismic source, at most; however, very few specific data are available on levels of seismic signals that might damage these animals. This premise is based on the peak pressure and rise/decay time characteristics of seismic airgun arrays currently in use around the world.

Some studies have suggested that seismic survey sound has a limited pathological impact on early developmental stages of crustaceans (Pearson et al., 1994; Christian et al., 2003; DFO, 2004). However, the impacts appear to be either temporary or insignificant compared to what occurs under natural conditions. Controlled field experiments on adult crustaceans (Christian et al., 2003, 2004; DFO, 2004) and adult cephalopods (McCauley et al., 2000a,b) exposed to seismic survey sound have not resulted in any significant pathological impacts on the animals. It has been suggested that exposure to commercial seismic survey activities has injured giant squid (Guerra et al., 2004), but the article provides little evidence to support this claim. Recent work by Andre et al. (2011) purports to present the first morphological and ultrastructural evidence of massive acoustic trauma (i.e., permanent and substantial alterations of statocyst sensory hair

cells) in four cephalopod species subjected to low-frequency sound. The cephalopods, primarily cuttlefish, were exposed to continuous 50 to 400 Hz sinusoidal wave sweeps (100% duty cycle and 1 s sweep period) for two hours while captive in relatively small tanks (one 2,000 liter [L, 2m³] and one 200 L [0.2 m³] tank), and reported morphological and ultrastructural evidence of massive acoustic trauma (i.e., permanent and substantial alterations of statocyst sensory hair cells). The received SPL was reported as 157±5 dB re 1 µPa, with peak levels at 175 dB re 1 µPa. As in the McCauley *et al.* (2003) paper on sensory hair cell damage in pink snapper as a result of exposure to seismic sound, the cephalopods were subjected to higher sound levels than they would be under natural conditions, and they were unable to swim away from the sound source.

Physiological Effects - Physiological effects refer mainly to biochemical responses by marine invertebrates to acoustic stress. Such stress potentially could affect invertebrate populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses (i.e., changes in haemolymph levels of enzymes, proteins, etc.) of crustaceans have been noted several days or months after exposure to seismic survey sounds (Payne *et al.*, 2007). The periods necessary for these biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and of the sound stimulus.

Behavioral Effects – There is increasing interest in assessing the possible direct and indirect effects of seismic and other sounds on invertebrate behavior, particularly in relation to the consequences for fisheries. Changes in behavior could potentially affect such aspects as reproductive success, distribution, susceptibility to predation, and catchability by fisheries. Studies investigating the possible behavioral effects of exposure to seismic survey sound on crustaceans and cephalopods have been conducted on both uncaged and caged animals. In some

cases, invertebrates exhibited startle responses (e.g., squid in McCauley *et al.*, 2000a,b). In other cases, no behavioral impacts were noted (e.g., crustaceans in Christian *et al.*, 2003, 2004; DFO 2004). There have been anecdotal reports of reduced catch rates of shrimp shortly after exposure to seismic surveys; however, other studies have not observed any significant changes in shrimp catch rate (Andriguetto-Filho *et al.*, 2005). Similarly, Parry and Gason (2006) did not find any evidence that lobster catch rates were affected by seismic surveys. Any adverse effects on crustacean and cephalopod behavior or fisheries attributable to seismic survey sound depend on the species in question and the nature of the fishery (season, duration, fishing method).

OBS Deployment – A total of approximately 10 OBSs will be deployed during the proposed survey. L-DEO OBS08 model broadband OBSs will be used during the cruise. This type of OBS has a height of approximately 122 cm and a width and depth of 76.2 x 106.7 cm. The anchor is made of two steel cylinders approximately 15 cm in diameter and 46 cm in length. Each cylinder weighs approximately 75 lbs in air. OBSs will remain on the seafloor to continue to collect data for approximately one year. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9 to 11 kHz, and a response is received at a frequency of 9 to 13 kHz. The burn-wire release assembly is then activated and the instrument is released from the anchor to float to the surface. OBS anchors will be left behind upon equipment recovery. Although OBS placement will disrupt a very small area of seafloor habitat and could disturb benthic invertebrates, the impacts are expected to be localized and transitory.

Proposed Mitigation

In order to issue an Incidental Take Authorization (ITA) under section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity,

and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and the availability of such species or stock for taking for certain subsistence uses.

SIO has based the mitigation measures described herein, to be implemented for the proposed seismic survey, on the following:

- (1) Protocols used during previous SIO seismic research cruises as approved by NMFS;
- (2) Previous IHA applications and IHAs approved and authorized by NMFS; and
- (3) Recommended best practices in Richardson *et al.* (1995), Pierson *et al.* (1998), and Weir and Dolman, (2007).

Planning Phase – The PIs worked with SIO and NSF to identify potential time periods to carry out the survey taking into consideration key factors such as environmental conditions (i.e., the seasonal presence of marine mammals), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the Melville. Most marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed survey likely would result in no net benefits for those species. Baleen whales are most common south of the survey area between February and June, whereas odontocetes were most commonly observed between October and November. After considering what energy source level was necessary to achieve the research goals, the PIs determined the use of the two GI airgun array with a maximum total volume of 210 in³ would be required. Given the research goals, location of the survey and associated deep water, this energy source level was viewed appropriate. The location of the survey was informed and adjusted based on the latest scientific information on the epicenter of the February 27, 2010 earthquake; survey location is critical for collecting the data for the overall research activity and meeting research objectives.

To reduce the potential for disturbance from acoustic stimuli associated with the activities, SIO and/or its designees has proposed to implement the following mitigation measures for marine mammals:

- (1) Proposed exclusion zones;
- (2) Speed or course alteration;
- (3) Shut-down procedures; and
- (4) Ramp-up procedures.

Proposed Exclusion Zones – Received sound levels have been modeled by L-DEO for a number of airgun configurations, including two 45 in³ GI airguns, in relation to distance and direction from the airguns (see Figure 2 of the IHA application). The model does not allow for bottom interactions, and is most directly applicable to deep water. Based on the modeling, estimates of the maximum distances from the source where sound levels are predicted to be 190, 180, and 160 dB re 1 μ Pa (rms) in deep water were determined (see Table 1 above).

Empirical data concerning the 190, 180, and 160 dB (rms) distances were acquired for various airgun arrays based on measurements during the acoustic verification studies conducted by L-DEO in the northern GOM in 2003 (Tolstoy *et al.*, 2004) and 2007 to 2008 (Tolstoy *et al.*, 2009). Results of the 36 airgun array are not relevant for the two GI airguns to be used in the proposed survey. The empirical data for the 6, 10, 12, and 20 airgun arrays indicate that, for deep water, the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy *et al.*, 2004). Measurements were not made for the two GI airgun array in deep water, however, SIO proposes to use the EZ predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative give the empirical results for the other arrays.

The 180 and 190 dB radii are shut-down criteria applicable to cetaceans and pinnipeds, respectively, as specified by NMFS (2000); these levels were used to establish the EZs. If the PSO detects marine mammal(s) within or about to enter the appropriate EZ, the airguns will be shut-down immediately.

Speed or Course Alteration - If a marine mammal is detected outside the EZ and, based on its position and the relative motion, is likely to enter the EZ, the vessel's speed and/or direct course could be changed. This would be done if operationally practicable while minimizing the effect on the planned science objectives. The activities and movements of the marine mammal (relative to the seismic vessel) will then be closely monitored to determine whether the animal is approaching the applicable EZ. If the animal appears likely to enter the EZ, further mitigative actions will be taken, i.e., either further course alterations or a shut-down of the seismic source. Typically, during seismic operations, the source vessel is unable to change speed or course and one or more alternative mitigation measures will need to be implemented.

Shut-down Procedures - SIO will shut down the operating airgun(s) if a marine mammal is seen outside the EZ for the airgun(s), and if the vessel's speed and/or course cannot be changed to avoid having the animal enter the EZ, the seismic source will be shut-down before the animal is within the EZ. If a marine mammal is already within the EZ when first detected, the seismic source will be shut-down immediately.

Following a shut-down, SIO will not resume airgun activity until the marine mammal has cleared the EZ. SIO will consider the animal to have cleared the EZ if:

- A PSO has visually observed the animal leave the EZ, or

- A PSO has not sighted the animal within the EZ for 15 min for species with shorter dive durations (i.e., small odontocetes or pinnipeds), or 30 min for species with longer dive durations (i.e., mysticetes and large odontocetes, including sperm, killer, and beaked whales).

Ramp-up Procedures - SIO will follow a ramp-up procedure when the airgun array begins operating after a specified period without airgun operations or when a shut-down has exceeded that period. SIO proposes that, for the present cruise, this period would be approximately 15 min. SIO has used similar periods (approximately 15 min) during previous SIO surveys.

Ramp-up will begin with a single GI airgun (45 in³). The second GI airgun (45 in³) will be added after five min. During ramp-up, the PSOs will monitor the EZ, and if marine mammals are sighted, SIO will implement a shut-down as though both GI airguns 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, SIO will not commence the ramp-up. If one airgun has operated, ramp-up to full power will be permissible at night or in poor visibility, on the assumption that marine mammals will be alerted to the approaching seismic vessel by the sounds from the single airgun and could move away if they choose. A ramp-up from a shut-down may occur at night, but only where the EZ is small enough to be visible. SIO will not initiate a ramp-up of the airguns if a marine mammal is sighted within or near the applicable EZs during the day or close to the vessel at night.

NMFS has carefully evaluated the applicant's proposed mitigation measures and has considered a range of other measures in the context of ensuring that NMFS prescribes the means of effecting the least practicable adverse impact on the affected marine mammal species and stocks and their habitat. NMFS's evaluation of potential measures included consideration of the following factors in relation to one another:

(1) The manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals;

(2) The proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and

(3) The practicability of the measure for applicant implementation.

Based on NMFS's evaluation of the applicant's proposed measures, as well as other measures considered by NMFS or recommended by the public, NMFS has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable adverse impacts on marine mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed Monitoring and Reporting

In order to issue an ITA for an activity, section 101(a)(5)(D) of the MMPA states that NMFS must set forth "requirements pertaining to the monitoring and reporting of such taking." The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for IHAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the action area.

Monitoring

SIO proposes to sponsor marine mammal monitoring during the proposed project, in order to implement the proposed mitigation measures that require real-time monitoring, and to satisfy the anticipated monitoring requirements of the IHA. SIO's proposed Monitoring Plan is described below this section. SIO understands that this monitoring plan will 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. SIO 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

PSOs will be based aboard the seismic source vessel and will watch for marine mammals near the vessel during daytime airgun operations and during any ramp-ups at night. PSOs will also watch for marine mammals near the seismic vessel for at least 30 min prior to the ramp-up of airgun operations after an extended shut-down (i.e., greater than approximately 15 min for this proposed cruise). When feasible, PSOs will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavior with and without airgun operations and between acquisition periods. Based on PSO observations, the airguns will be shut-down when marine mammals are observed within or about to enter a designated EZ. The EZ is a region in which a possibility exists of adverse effects on animal hearing or other physical effects.

During seismic operations in the south-eastern Pacific Ocean, three PSOs will be based aboard the Melville. SIO will appoint the PSOs with NMFS's concurrence. At least one PSO will monitor the EZs during seismic operations. Observations will take place during ongoing daytime operations and nighttime ramp-ups of the airguns. PSO(s) will be on duty in shifts of duration no longer than 4 hr. The vessel crew will also be instructed to assist in detecting marine mammals.

The Melville is a suitable platform for marine mammal observations of protected species. The primary observer platform is located one deck below and forward of the bridge (02

level, 12.46 m [40.9 ft] above the waterline), affording relatively unobstructed 180° forward view. A pair of Big-eye binoculars is mounted in this location. The open deck continues along both the port and starboard sides, and opens up to an aft deck stretching across the full width of the vessel. PSOs have views in a full 360° by walking along this deck. In extremely inclement weather, the PSOs move on to the bridge (03 level, 15.5 m [50.6 ft] above the water line). There they will have a 360° view through the windows.

During daytime, the PSVOs will scan the area around the vessel systematically with reticle binoculars (e.g., 7 x 50 Fujinon), Big-eye binoculars (25 x 150), optical range finders and with the naked eye. During darkness, night vision devices (NVDs) will be available, when required. The PSOs will be in wireless communication with the vessel's officers on the bridge and scientists in the vessel's operations laboratory, so they can advise promptly of the need for avoidance maneuvers or seismic source shut-down. When marine mammals are detected within or about to enter the designated EZ, the airguns will immediately be shut-down if necessary. The PSO(s) will continue to maintain watch to determine when the animal(s) are outside the EZ by visual confirmation. Airgun operations will not resume until the animal is confirmed to have left the EZ, or if not observed after 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive durations (mysticetes and large odontocetes, including sperm, killer, and beaked whales).

PSO Data and Documentation

PSOs will record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data will be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They will also provide information needed to order a shut-down of the airguns when a

marine mammal is within or near the EZ. Observations will also be made during daytime periods when the Melville is underway without seismic operations (i.e., transits to, from, and through the study area) to collect baseline biological data.

When a sighting is made, the following information about the sighting will 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, Beaufort sea state, visibility, and sun glare.

The data listed under (2) will 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 as well as information regarding shut-downs of the seismic source, will be recorded in a standardized format. The data accuracy will be verified by the PSOs at sea, and preliminary reports will be prepared during the field program and summaries forwarded to the operating institution's shore facility and to NSF weekly or more frequently.

Vessel-based observations by the PSO will provide the following information:

1. The basis for real-time mitigation (airgun shut-down).
2. Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS.

3. Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted.

4. Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity.

5. Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

SIO will submit a report to NMFS and NSF within 90 days after the end of the cruise. The report will describe the operations that were conducted and sightings of marine mammals near the operations. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report will summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the number and nature of exposures that could result in potential “takes” of marine mammals by harassment or in other ways. After the report is considered final, it will be publicly available on the NMFS and NSF websites.

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), SIO will immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS at 301-427-8401 and/or by email to Michael.Payne@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Southwest Regional Stranding Coordinators (Joe.Cordaro@noaa.gov and Sarah.Wilkin@noaa.gov). The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;

- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with SIO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS via letter or email, or telephone.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), SIO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Michael.Payne@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Southwest Regional Office (562-980-4017) and/or by email to the Southwest Regional Stranding Coordinators (Joe.Cordaro@noaa.gov and Sarah.Wilkin@noaa.gov). The report must include the same information identified in the

paragraph above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether modifications in the activities are appropriate.

In the event that SIO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Michael.Payne@noaa.gov and Howard.Goldstein@noaa.gov, and the NMFS Southwest Regional Office (562-980-4017), and/or by email to the Southwest Regional Stranding Coordinators (Joe.Cordaro@noaa.gov and Sarah.Wilkin@noaa.gov), within 24 hours of discovery. SIO will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

Estimated Take by Incidental Harassment

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

Only take by Level B harassment is anticipated and proposed to be authorized as a result of the proposed marine seismic survey in the south-eastern Pacific Ocean. Acoustic stimuli (i.e., increased underwater sound) generated during the operation of the seismic airgun array may have the potential to cause marine mammals in the survey area to be exposed to sounds at or

greater than 160 dB or cause temporary, short-term changes in behavior. There is no evidence that the planned activities could result in injury, serious injury, or mortality within the specified geographic area for which SIO seeks the IHA. The required mitigation and monitoring measures will minimize any potential risk for injury, serious injury, or mortality.

The following sections describe SIO's methods to estimate take by incidental harassment and present the applicant's estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The estimates are based on a consideration of the number of marine mammals that could be disturbed appreciably by operations with the two GI airgun array to be used during approximately 1,810 km (977.3 nmi) (includes primary and secondary lines and an additional 25 percent contingency) of survey lines in the south-eastern Pacific Ocean.

SIO assumes that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES and SBP 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 previously. Such reactions are not considered to constitute "taking" (NMFS, 2001). Therefore, SIO provides no additional allowance for animals that could be affected by sound sources other than airguns.

Extensive systematic ship-based surveys have been conducted by NMFS SWFSC for marine mammals in the ETP. SIO used densities from five sources:

- (1) SWFSC has recently developed habitat modeling as a method to estimate cetacean densities on a finer spatial scale than traditional line-transect analyses by using a continuous

function of habitat variables, e.g., sea surface temperature, depth, distance from shore, and prey density (Barlow et al., 2009). For the ETP, the models are based on data from 12 SWFSC ship-based cetacean and ecosystem assessment surveys conducted during July to December from 1986 to 2006. The models have been incorporated into a web-based Geographic Information System (GIS) developed by Duke University's Department of Defense Strategic Environmental Research and Development Program (SERDP) team in close collaboration with the SWFSC SERDP team Read et al., 2009). For 11 cetacean species in the model, SIO used the GIS to obtain mean densities near the proposed survey area, i.e., in a rectangle bounded by 4° to 12° South and 75° to 85° West, which was the south-eastern extent of the model;

(2) For species sighted in SWFSC surveys whose sample sizes were too small to model density, SIO used densities from the surveys conducted during summer and fall 1986 to 1996, as summarized by Ferguson and Barlow (2001). Densities were calculated from Ferguson and Barlow (2003) for 5° x 5° blocks that include the proposed survey areas and corridors: Blocks 139, 159, 160, 200, 201, 202, 212, 213, and 219. Those blocks included 27,275 km (14727.3 nmi) of survey effort in Beaufort sea states 0 to 5, and 2,564 km (1,384.5 nmi) of survey effort in Beaufort sea states 0 to 2. Densities were obtained for an additional five species that were sighted in one or more of those blocks;

(3) For dusky dolphins, SIO used the mean densities reported for Area A from aerial surveys in North and Central Patagonia (Shiavini et al., 1999), corrected for $f(0)$, but not $g(0)$. Since the closest density estimates were taken south of the proposed survey area, where dusky dolphin abundance is higher, SIO used 10 percent of the reported density to account for the decreased abundance of dusky dolphins in the proposed survey area;

(4) For Chilean dolphins, SIO used the estimated density of Chilean dolphins in Patagonia from Heinrich (2006). The extralimital, offshore distribution of Chilean dolphins in the proposed survey area was corrected for by taking 1 percent of the densities reported by Heinrich (2006);

(5) For blue whales, SIO used the densities reported by Galletti-Vernazzani and Cabrera (2009) from aerial surveys in Patagonia in March 2007 and April in 2009 that took place south of the survey site (39° South to 44° South). The density estimates were corrected for $f(0)$ and $g(0)$. Given the higher abundance of blue whales south of the survey site, SIO corrected the reported density for the proposed survey area by reducing the density by 50 percent.

For two species for which there are only unconfirmed sightings in the region, the sei and fin whale, arbitrary low densities (equal to the density of the species with the lowest calculated density) were assigned. The same arbitrary low density was assigned to southern right whale dolphins and Burmeister's porpoise, where no confirmed sightings were made within the survey region. In addition, there were no density estimates available for humpback whales, minke whales, and Peale's dolphins, but confirmed sightings have been made near the survey area. SIO arbitrarily assigned a density estimate of 0.8 animals/1,000 km², which was similar to the densities reported for uncommon species in the area.

Oceanographic conditions, including occasional El Nino and La Nina events, influence the distribution and numbers of marine mammals present in the ETP and SEP, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (e.g., Escorza-Trevino, 2009). Thus, for some species the densities derived from recent surveys may not be representative of densities that will be encountered during the proposed seismic survey.

SIO used estimated densities (see Table 3 of the application) for each cetacean species likely to occur in the proposed study area, i.e., species for which SIO obtained or assigned densities. The densities had been corrected, by the authors, for both trackline detectability and availability bias. Trackline detection probability bias is associated with diminishing sightability with increasing lateral distance from the trackline, and is measured by $f(0)$. Availability bias refers to the fact that there is less-than-100% probability of sighting an animal that is present along the survey trackline $f(0)$, and it is measured by $g(0)$. Corrections for $f(0)$ and $g(0)$ were made where mentioned above. The densities are given in Table 3 of SIO's IHA application.

SIO's estimates of exposures to various sound levels assume that the proposed surveys will be fully completed; in fact, the ensonified areas calculated using the planned number of line-km have been increased by 25 percent to accommodate turns, lines that may need to be repeated, equipment testing, etc. As is typical during offshore ship surveys, inclement weather and equipment malfunctions are likely to cause delays and may limit the number of useful line-kilometers of seismic operations that can be undertaken. Furthermore, any marine mammal sightings within or near the designated EZs will result in the shut-down of seismic operations as a mitigation measure. Thus, the following estimates of the numbers of marine mammals potentially exposed to sound levels of 160 dB re 1 μ Pa (rms) are precautionary and probably overestimate the actual numbers of marine mammals that might be involved. These estimates also assume that there will be no weather, equipment, or mitigation delays, which is highly unlikely.

SIO estimated the number of different individuals that may be exposed to airgun sounds with received levels greater than or equal to 160 dB re 1 μ Pa (rms) on one or more occasions by considering the total marine area that would be within the 160 dB radius around the operating

airgun array on at least one occasion, along with the expected density of marine mammals in the area. The proposed seismic lines are not in close proximity, which minimizes the number of times an individual marine mammal may be exposed during the proposed survey; the area including the overlap is only 1.2 times the area excluding overlap.

The numbers of different individuals potentially exposed to greater than or equal to 160 dB (rms) were calculated by multiplying the expected species density times the anticipated area to be ensonified during airgun operations. The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by “drawing” the applicable 160 dB buffer (see Table 1 of the IHA application) around each seismic line, and then calculating the total area within the buffers. Areas where overlap occurred (because of crossing lines) were included only once when estimating the number of individuals exposed.

Applying the approach described above, approximately 1,448.4 km² (422.3 nmi²) would be within the 160 dB isopleth on one or more occasions during the proposed survey (including primary and secondary lines). The total ensonified area used to calculate estimated numbers exposed was approximately 1,810.5 km² [527.9 nmi²] and includes the additional 25 percent increase in the calculated area for contingency. Because this approach does not allow for turnover in the marine mammal populations in the study area during the course of the survey, the actual number of individuals exposed could be underestimated, although the conservative (i.e., probably overestimated) line-kilometer distances used to calculate the area may offset this. Also, the approach assumes that no cetaceans will move away from or toward the trackline as the Melville approaches in response to increasing sound levels prior to the time the levels reach 160 dB. Another way of interpreting the estimates that follow is that they represent the number of

individuals that are expected (in the absence of a seismic program) to occur in the waters that will be exposed to greater than or equal to 160 dB re 1 μ Pa (rms).

Table 3 (Table 3 of the IHA application) shows the estimates of the number of different individual marine mammals that potentially could be exposed to greater than or equal to 160 dB re 1 μ Pa (rms) during the seismic survey if no animals moved away from the survey vessel. The requested take authorization is given in Table 3 (below; the far right column of Table 3 of the IHA application). For ESA listed species, the requested take authorization has been increased to the mean group size in southern Chile where available (Viddi et al., 2010) or the ETP (Wade and Gerodette, 1993), where the calculated number of individuals exposed was between 0.05 and the mean group size (i.e., for sei, fin, humpback, and sperm whales). For species not listed under the ESA that could occur in the study area, the requested take authorization has been increased to the mean group size in the ETP (Wade and Gerodette, 1993) or southern Chile (Viddi et al., 2010); Zamorano-Abramson et al., 2010) in cases where the calculated number of individuals exposed was between one and the mean group size. For delphinids where typically large group sizes are encountered, the requested take authorization was increased to the mean group size in southern Chile (Aguauo et al., 1998; Viddi et al., 2010; Zamarano-Abramson et al., 2010) if the calculated number was greater than one, but less than the mean group size.

The best estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels greater than or equal to 160 dB re 1 μ Pa (rms) during the proposed survey is 561 (see Table 3 of the IHA application). That total includes: 1 humpback, 1 minke, 2 Bryde's, 4 blue, and 7 sperm whales, 1 Cuvier's, 1 Blainville's, and 1 unidentified Mesoplodon beaked whale, 15 rough-toothed, 72 bottlenose, 134 spinner, 123 striped, 254 short-beaked common, 4 Peale's, 67 dusky, and 4 Chilean dolphins, and 1 false killer, 2 killer, and 22 long-

finned pilot whales, which would represent less than 1% of the regional populations for any of the respective species. Most (96.4%) of the cetaceans potentially exposed are delphinids; rough-toothed, short-beaked common, striped, spinner, bottlenose, Risso's, and dusky dolphins and long-finned pilot whales are estimated to be the most common species in the proposed study area. Due to the extralimital distribution of pinnipeds in the study area, no pinnipeds are expected to be encountered during the proposed survey.

Table 3. Estimates of the possible numbers of marine mammals exposed to different sound levels ≥ 160 dB during SIO's proposed seismic survey in the south-eastern Pacific Ocean during May, 2012.

Species	Estimated Number of Individuals Exposed to Sound Levels ≥ 160 dB re $1 \mu\text{Pa}^1$	Requested Take Authorization	Approximate Percent of Regional Population (For Requested Take) ²
Mysticetes			
Humpback whale	1	3*	0.1
Minke whale	1	2*	<0.01
Bryde's whale	2	2	<0.01
Sei whale	0	0	NA
Fin whale	0	0	NA
Blue whale	4	4	0.3
Odontocetes			
Sperm whale	7	8*	0.03
Pygmy sperm whale	0	0	NA
Dwarf sperm whale	0	0	NA
Cuvier's beaked whale	1	1	<0.01
Blainville's beaked whale	1	1	<0.01
Gray's beaked whale	0	0	NA
Hector's beaked whale	0	0	NA
Strap-toothed beaked whale	0	0	NA
Unidentified <i>Mesoplodon</i> spp.	1	1	<0.01
Rough-toothed dolphin	8	15*	0.01
Bottlenose dolphin	31	72*	0.02
Spinner dolphin	65	134*	<0.01
Striped dolphin	123	123	0.01
Short-beaked common dolphin	201	254*	0.01
Risso's dolphin	18	18	0.02
False killer whale	1	1	<0.01
Killer whale	2	2	0.02
Long-finned pilot whale	22	22	0.01
Peale's dolphin	1	4*	NA
Dusky dolphin	67	67	0.92
Southern right whale dolphin	0	0	NA
Chilean dolphin	4	4	0.4
Burmeister's porpoise	0	0	NA
Pinnipeds			
South American fur seal	0	0	NA
Juan Fernandez fur seal	0	0	NA
South American sea lion	0	0	NA
Southern elephant seal	0	0	NA

¹ Estimates are based on densities from Table 2 (Table 3 of the IHA application) and ensounded areas (including 25% contingency) for 160 dB of 1,810.5 km².

² Regional population size estimates are from Table 2 (see Table 2 of the IHA application); NA means not available.

* Requested authorized take was increased to mean group size for delphinids if calculated numbers were between 1 and mean group size, and increased to the mean group size if calculated values were greater than 0.05 for endangered species.

Encouraging and Coordinating Research

SIO and NSF will coordinate the planned marine mammal monitoring program associated with the seismic survey in the south-eastern Pacific Ocean with any parties that may have or express an interest in the proposed seismic survey area. SIO and NSF have coordinated, and will continue to coordinate, with other applicable Federal agencies as required, and will comply with their requirements. Pursuant to IHA requirements, SIO will submit a monitoring report to NMFS 90 days after the proposed survey. PSO data collected during the survey will be submitted to OBIS Seamap and will be made available on the NSF website for interested parties and researchers.

Negligible Impact and Small Numbers Analysis and Preliminary Determination

NMFS has defined “negligible impact” in 50 CFR 216.103 as “...an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.”

In making a negligible impact determination, NMFS evaluated factors such as:

- (1) The number of anticipated injuries, serious injuries, or mortalities;
- (2) The number, nature, and intensity, and duration of Level B harassment (all relatively limited);
- (3) The context in which the takes occur (i.e., impacts to areas of significance, impacts to local populations, and cumulative impacts when taking into account successive/contemporaneous actions when added to baseline data);
- (4) The status of stock or species of marine mammals (i.e., depleted, not depleted, decreasing, increasing, stable, and impact relative to the size of the population);
- (5) Impacts on habitat affecting rates of recruitment/survival; and

(6) The effectiveness of monitoring and mitigation measures (i.e., the manner and degree in which the measure is likely to reduce adverse impacts to marine mammals, the likely effectiveness of the measures, and the practicability of implementation).

For reasons stated previously in this document, the specified activities associated with the marine seismic survey are not likely to cause PTS, or other non-auditory injury, serious injury, or death because:

(1) The likelihood that, given sufficient notice through relatively slow ship speed, marine mammals are expected to move away from a noise source that is annoying prior to its becoming potentially injurious;

(2) The potential for temporary or permanent hearing impairment is relatively low and would likely be avoided through the incorporation of the required monitoring and mitigation measures (described above);

(3) The fact that pinnipeds would have to be closer than 10 m (32.8 ft) in deep water when the two GI airgun array is in use at 2 m (6.6 ft) tow depth from the vessel to be exposed to levels of sound believed to have even a minimal chance of causing PTS;

(4) The fact that cetaceans would have to be closer than 40 m (131.2 ft) in deep water when the two GI airgun array is in 2 m tow depth from the vessel to be exposed to levels of sound believed to have even a minimal chance of causing PTS; and

(5) The likelihood that marine mammal detection ability by trained PSOs is high at close proximity to the vessel.

No injuries, serious injuries, or mortalities are anticipated to occur as a result of SIO's planned marine seismic survey, and none are authorized by NMFS. Only short-term, behavioral disturbance is anticipated to occur due to the brief and sporadic duration of the survey activities.

Table 3 in this document outlines the number of Level B harassment takes that are anticipated as a result of the activities. Due to the nature, degree, and context of Level B (behavioral) harassment anticipated and described (see Potential Effects on Marine Mammals section above) in this notice, the activity is not expected to impact rates of recruitment or survival for any affected species or stock.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (i.e., 24 hr cycle). Behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall et al., 2007). While seismic operations are anticipated to occur on consecutive days, the entire duration of the survey is not expected to last more than 15 days and the Melville will be continuously moving along planned tracklines. Therefore, the seismic survey will be increasing sound levels in the marine environment surrounding the vessel for several weeks in the study area. Of the 32 marine mammal species under NMFS jurisdiction that are known to or likely to occur in the study area, five are listed as endangered under the ESA: humpback, sei, fin, blue, and sperm whale. These species are also considered depleted under the MMPA. There is generally insufficient data to determine population trends for the other depleted species in the study area. To protect these animals (and other marine mammals in the study area), SIO must cease or reduce airgun operations if animals enter designated zones. No injury, serious injury, or mortality is expected to occur and due to the nature, degree, and context of the Level B harassment anticipated, the activity is not expected to impact rates of recruitment or survival.

As mentioned previously, NMFS estimates that 20 species of marine mammals under its jurisdiction could be potentially affected by Level B harassment over the course of the proposed

IHA. For each species, these numbers are small (each less than one percent) relative to the regional population size. The population estimates for the marine mammal species that may be taken by harassment were provided in Table 2 of this document.

NMFS's practice has been to apply the 160 dB re 1 μ Pa (rms) received level threshold for underwater impulse sound levels to determine whether take by Level B harassment occurs. Southall et al. (2007) provide a severity scale for ranking observed behavioral responses of both free-ranging marine mammals and laboratory subjects to various types of anthropogenic sound (see Table 4 in Southall et al. [2007]).

NMFS has preliminarily determined, provided that the aforementioned mitigation and monitoring measures are implemented, that the impact of conducting a marine seismic survey in the south-eastern Pacific Ocean, May, 2012, may result, at worst, in a temporary modification in behavior and/or low-level physiological effects (Level B harassment) of small numbers of certain species of marine mammals. See Table 3 (above) for the requested authorized take numbers of cetaceans and pinnipeds.

While behavioral modifications, including temporarily vacating the area during the operation of the airgun(s), may be made by these species to avoid the resultant acoustic disturbance, the availability of alternate areas within these areas and the short and sporadic duration of the research activities, have led NMFS to preliminarily determine that this action will have a negligible impact on the species in the specified geographic region.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the mitigation and monitoring measures, NMFS preliminarily finds that SIO's planned research activities, will result in the incidental take of small numbers of marine mammals, by Level B

harassment only, and that the total taking from the marine seismic survey will have a negligible impact on the affected species or stocks of marine mammals; and that impacts to affected species or stocks of marine mammals have been mitigated to the lowest level practicable.

Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses

Section 101(a)(5)(D) also requires NMFS to determine that the authorization will not have an unmitigable adverse effect on the availability of marine mammal species or stocks for subsistence use. There are no relevant subsistence uses of marine mammals in the study area (offshore waters of the south-eastern Pacific Ocean off of Chile) that implicate MMPA section 101(a)(5)(D).

Endangered Species Act

Of the species of marine mammals that may occur in the proposed survey area, several are listed as endangered under the ESA, including the humpback, sei, fin, blue, and sperm whale. Under section 7 of the ESA, NSF has initiated formal consultation with the NMFS, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, on this proposed seismic survey. NMFS's Office of Protected Resources, Permits and Conservation Division, has initiated formal consultation under section 7 of the ESA with NMFS's Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, to obtain a Biological Opinion evaluating the effects of issuing the IHA on threatened and endangered marine mammals and, if appropriate, authorizing incidental take. NMFS will conclude formal section 7 consultation prior to making a determination on whether or not to issue the IHA. If the IHA is issued, NSF and SIO, in addition to the mitigation and monitoring requirements included in the IHA, will be required to comply with the Terms and Conditions of the Incidental Take Statement corresponding to NMFS's Biological Opinion issued to both NSF and NMFS's Office

of Protected Resources.

National Environmental Policy Act (NEPA)

With its complete application, NSF and SIO provided NMFS a draft “National Environmental Policy Act Analysis Pursuant to Executive Order 12114 of a Marine Geophysical Survey by the R/V Melville in the South-Eastern Pacific Ocean, May 2012” and NMFS will prepare an Environmental Assessment (EA) titled “Issuance of an Incidental Harassment Authorization to the Scripps Institution of Oceanography to Take Marine Mammals by Harassment Incidental to a Marine Geophysical Survey in the South-Eastern Pacific Ocean, May, 2012.” This EA will incorporate the NSF’s NEPA analysis by reference pursuant to 40 CFR 1502.21 and NOAA Administrative Order (NAO) 216-6 § 5.09(d). NMFS’s EA will rely on the environmental information disclosed and referenced in this notice and NMFS will evaluate public comments provided in responses to this notice when preparing its EA. Prior to making a final decision on the SIO’s IHA application, NMFS will make a decision of whether or not to issue a Finding of No Significant Impact (FONSI).

Proposed Authorization

NMFS proposes to issue an IHA to SIO for conducting a marine geophysical survey in the south-eastern Pacific Ocean, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. The duration of the IHA would not exceed one year from the date of its issuance.

Information Solicited

NMFS requests interested persons to submit comments and information concerning this proposed project and NMFS's preliminary determination of issuing an IHA (see ADDRESSES). Concurrent with the publication of this notice in the Federal Register, NMFS is forwarding copies of this application to the Marine Mammal Commission and its Committee of Scientific Advisors.

Dated: March 7, 2012

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[FR Doc. 2012-6054 Filed 03/12/2012 at 8:45 am; Publication Date: 03/13/2012]