BILLING CODE 3510-22-P

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648-XG948

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Marine Geophysical Surveys in the Northeast Pacific Ocean

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

ACTION: Notice; proposed incidental harassment authorization; request for comments on proposed authorization and possible renewal.

SUMMARY: NMFS has received a request from the Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for authorization to take marine mammals incidental to a marine geophysical survey in the northeast Pacific Ocean. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an incidental harassment authorization (IHA) to incidentally take marine mammals during the specified activities. NMFS is also requesting comments on a possible one-year renewal that could be issued under certain circumstances and if all requirements are met, as described in *Request for Public Comments* at the end of this notice. NMFS will consider public comments prior to making any final decision on the issuance of the requested MMPA authorizations and agency responses will be summarized in the final notice of our decision.

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

ADDRESSES: Comments should be addressed to Jolie Harrison, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service. Physical comments should be sent to 1315 East-West Highway, Silver Spring, MD 20910 and electronic comments should be sent to *ITP.Fowler@noaa.gov*.

Instructions: NMFS is not responsible for comments sent by any other method, to any other address or individual, or received after the end of the comment period. Comments received electronically, including all attachments, must not exceed a 25-megabyte file size. Attachments to electronic comments will be accepted in Microsoft Word or Excel or Adobe PDF file formats only. All comments received are a part of the public record and will generally be posted online at *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection*-act without change. All personal identifying information (*e.g.*, name, address) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT: Amy Fowler, Office of Protected Resources, NMFS, (301) 427-8401. Electronic copies of the application and supporting documents, as well as a list of the references cited in this document, may be obtained online at: *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act*. In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:

Background

The MMPA prohibits the "take" of marine mammals, with certain exceptions. Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq*.) direct the Secretary of Commerce

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(as delegated to NMFS) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed incidental take authorization may be provided to the public for review.

Authorization for incidental takings 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 taking for subsistence uses (where relevant). Further, NMFS must prescribe the permissible methods of taking and other "means of effecting the least practicable adverse impact" on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stocks for taking for certain subsistence uses (referred to in shorthand as "mitigation"); and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth.

The NDAA (Pub. L. 108–136) removed the "small numbers" and "specified geographical region" limitations indicated above and amended the definition of "harassment" as it applies to a "military readiness activity." The definitions of all applicable MMPA statutory terms cited above are included in the relevant sections below.

National Environmental Policy Act

To comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) and NOAA Administrative Order (NAO) 216-6A, NMFS must review our proposed action (*i.e.*, the issuance of an incidental harassment authorization) with respect to potential impacts on the human environment.

Accordingly, NMFS is preparing an Environmental Assessment (EA) to consider the environmental impacts associated with the issuance of the proposed IHA. NMFS' EA will be made available at *https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act*.

We will review all comments submitted in response to this notice prior to concluding our NEPA process or making a final decision on the IHA request.

Summary of Request

On December 21, 2018, NMFS received a request from L-DEO for an IHA to take marine mammals incidental to a marine geophysical survey of the Axial Seamount in the Northeast Pacific Ocean. The application was deemed adequate and complete on May 3, 2019. L-DEO's request is for take of a small number of 26 species of marine mammals by Level B harassment and Level A harassment. Neither L-DEO nor NMFS expects serious injury or mortality to result from this activity and, therefore, an IHA is appropriate.

Description of Proposed Activity

Overview

Researchers from the University of Texas at Austin, University of Nevada Reno, University of California San Diego, with funding from the U.S. National Science Foundation (NSF), propose to conduct high-energy seismic surveys from Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) in the Northeast Pacific Ocean during summer 2019. The NSF-owned *Langseth* is operated by Columbia University's L-DEO under an existing Cooperative Agreement. The proposed two-dimensional (2-D) and three-dimensional (3-D) seismic surveys would occur in International Waters outside of the U.S. Exclusive Economic Zone (EEZ). The 2-D survey would use a 36-airgun towed array with a total discharge volume of ~6,600 cubic

inches (in^3); the 3-D survey would employ an 18-airgun array with a discharge volume of ~3,300 in^3.

The primary objectives of the surveys proposed by researchers from the University of Texas at Austin Institute for Geophysics (UTIG), the Nevada Seismological Laboratory at the University of Nevada Reno (UNR) and Scripps Institution of Oceanography (SIO) at the University of California San Diego, is to create a detailed 3-D image of the main and satellite magma reservoirs that set the Axial volcano's framework, image the 3-D fracture network and how they influence the magma bodies, and to connect the subsurface observations to the surface features. The main goal of the seismic program is to explore linkages between complex magma chamber structure, caldera dynamics, fluid pathways, and hydrothermal venting. Seismic data acquired during the proposed study could be used to evaluate earthquake, tsunami, and submarine landslide hazards.

Dates and Duration

The proposed surveys would be expected to last for 33 days, including approximately 19 days of seismic operations (approximately 16 days for the 3-D survey and three days for the 2-D survey), seven days of equipment deployment/retrieval, three days of operational contingency time (*e.g.*, infill, weather delays, etc.), two days for turns (no airguns firing) during the 3-D survey, and roughly two days of transit. R/V *Langseth* would leave out of and return to port in Astoria, OR, during summer (July/August) 2019.

Specific Geographic Region

The proposed surveys would occur within ~45.5 – 46.5° N, ~129.5 – 130.5° W. Representative survey tracklines are shown in Figure 1. Some deviation in actual track lines, including the order of survey operations, could be necessary for reasons such as science drivers,

poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Thus, the tracklines could occur anywhere within the coordinates noted above. The proposed surveys would be conducted in International Waters outside the U.S. EEZ. The surveys would occur in water depths ranging from 1,400 to 2,800 meters (m). The proposed survey area is approximately 423 kilometers (km) (229 miles (mi)) from shore at its closest point.
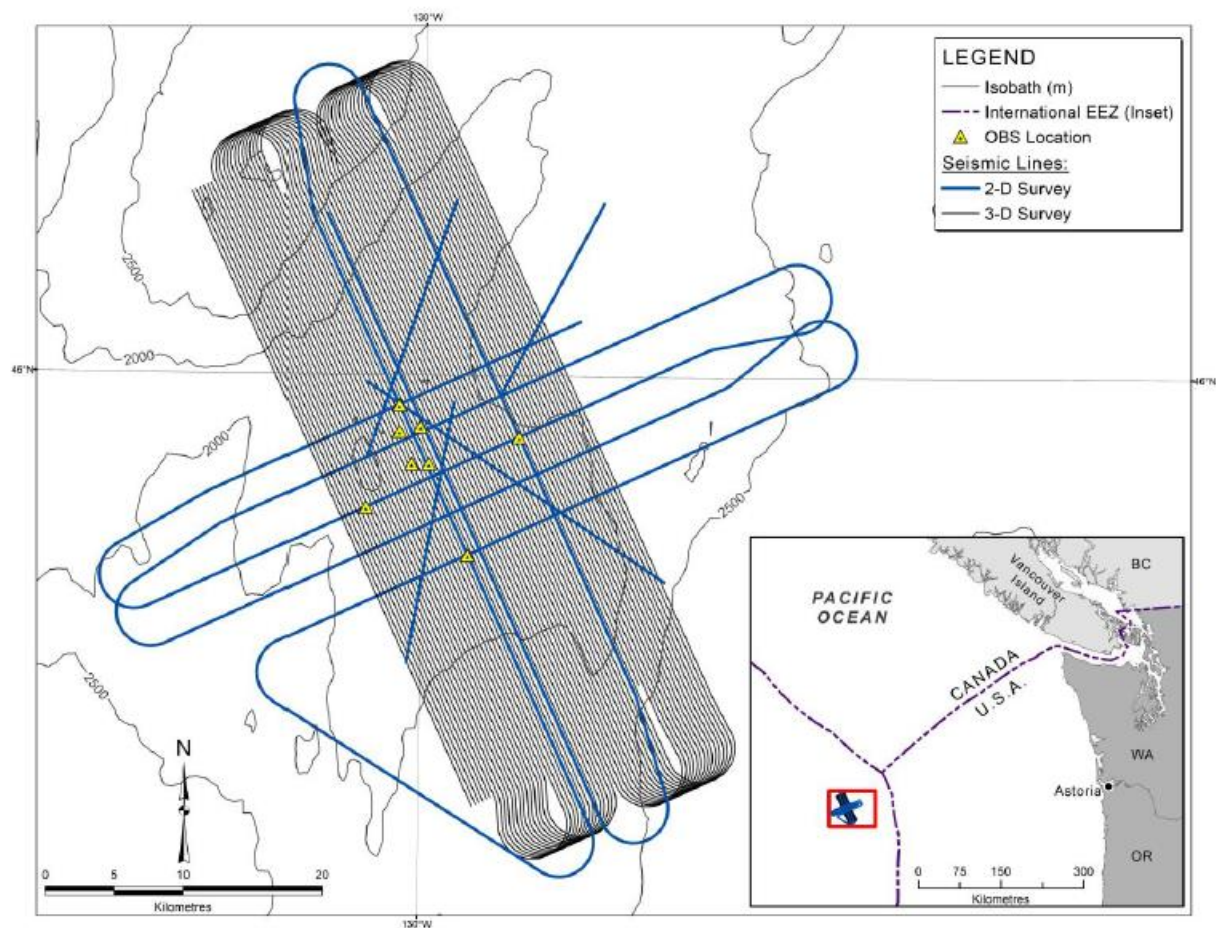
Figure 1. Location of the proposed seismic surveys in International Waters of the Northeast Pacific Ocean

Detailed Description of Specific Activity

The procedures to be used for the proposed surveys would be similar to those used during previous seismic surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Langseth*, which is owned by NSF and operated on its behalf by L-DEO.

R/V *Langseth* would first deploy four 6-km streamers and 18 airguns to conduct the 3-D multichannel seismic survey to examine the Axial volcano and associated rift axes within an approximate 17x40 km area. The 3-D survey would consist of a racetrack formation with 57 40-km long lines and a turning diameter of 8.5 km (Figure 1); no airguns would be firing during turns. The survey speed would be ~4.5 knots (kn) (8.3 km/hour) for the 3-D survey. The airgun array and streamers would then be recovered, and one 15-km streamer would be deployed along with 36 airguns to acquire eight ~26-km-long source-receiver offset 2-D reflection profiles that would look at deep-seated structure of magma delivery. During the 2-D survey, the airguns would be firing during turns to the next line, and the survey speed would be ~4.2 kn (7.8 km/hour).

The receiving system would consist of hydrophone streamers and up to eight ocean bottom seismometers (OBSs). The OBSs are long-term broadband instruments that would be left out for ~1 year and recovered by another vessel. They have a height and diameter of ~1 m, with an 80 kg anchor. To retrieve OBSs, an acoustic release transponder (pinger) is used to interrogate the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released to float to the surface from the anchor which is not retrieved. Four 6-km long hydrophone streamers would be used during 3-D data acquisition and one 15-km long streamer would be employed for 2-D

data acquisition. As the airguns are towed along the survey lines, the hydrophone streamer(s) would transfer the data to the on-board processing system, and the OBSs would receive and store the returning acoustic signals internally for later analysis.

A total of ~3,760 km of transect lines would be surveyed in the Northeast Pacific Ocean: ~3,196 km during the 3-D survey (including run ins and run outs) and 564 km during the 2-D survey. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. To account for unanticipated delays, 25 percent has been added in the form of operational days, which is equivalent to adding 25percent to the proposed line km to be surveyed.

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

Proposed mitigation, monitoring, and reporting measures are described in detail later in this document (please see *Proposed Mitigation* and *Proposed Monitoring and Reporting*).

Description of Marine Mammals in the Area of Specified Activities

Sections 3 and 4 of the application summarize available information regarding status and trends, distribution and habitat preferences, and behavior and life history, of the potentially affected species. Additional information regarding population trends and threats may be found in NMFS's Stock Assessment Reports (SARs; *https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments*) and more general information about

these species (*e.g.*, physical and behavioral descriptions) may be found on NMFS's website (*https://www.fisheries.noaa.gov/find-*species).

Table 1 lists all species with expected potential for occurrence in the survey area and summarizes information related to the population or stock, including regulatory status under the MMPA and ESA and potential biological removal (PBR), where known. For taxonomy, we follow Committee on Taxonomy (2016). PBR is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population (as described in NMFS's SARs). While no mortality is anticipated or authorized here, PBR and annual serious injury and mortality from anthropogenic sources are included here as gross indicators of the status of the species and other threats.

Marine mammal abundance estimates presented in this document represent the total number of individuals that make up a given stock or the total number estimated within a particular study or survey area. NMFS's stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises that stock. For some species, this geographic area may extend beyond U.S. waters. All managed stocks in this region are assessed in NMFS's U.S. Pacific and Alaska SARs (Caretta *et al.*, 2018; Muto *et al.*, 2018). All values presented in Table 1 are the most recent available at the time of publication and are available in the 2017 SARs (Caretta *et al.*, 2018; Muto *et al.*, 2018) and draft 2018 SARs (available online at: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/draft-marine-mammal-stock-assessment-reports*).

Table 1. Marine Mammals That Could Occur in the Survey Area.

Common name	Scientific name	Stock	ESA/MMPA status; Strategic (Y/N)[1]	Stock abundance (CV, N_{min}, most recent abundance survey)[2]	PBR	Annual M/SI[3]
Order Cetartiodactyla – Cetacea – Superfamily Mysticeti (baleen whales)						
Family Eschrichtiidae						
Gray whale	Eschrichtius robustus	Eastern North Pacific	-/-; N	26,960 (0.05, 25,849, 2016)	801	138
		Western North Pacific	E/D; Y	175 (0.05, 167, 2016)	0.07	Unknown
Family Balaenidae						
North Pacific right whale	Eubalaena japonica	Eastern North Pacific	E/D; Y	31 (0.226, 26, 2015)	0.05	0
Family Balaenopteridae (rorquals)						
Humpback whale	Megaptera novaeangliae	California/ Oregon/ Washington	-/-; Y	1,918 (0.03, 1,876, 2014)	11	> 9.2
Minke whale	Balaenoptera acutorostrata	California/ Oregon/ Washington	-/-; N	636 (0.72, 369, 2014)	3.5	> 1.3
Sei whale	Balaenoptera borealis	Eastern North Pacific	E/D; Y	519 (0.4, 374, 2014)	0.75	0
Fin whale	Balaenoptera physalus	California/ Oregon/ Washington	E/D; Y	9,029 (0.12, 8,127, 2014)	81	> 2.0
Blue whale	Balaenoptera musculus	Eastern North Pacific	E/D; Y	1,647 (0.07, 1,551, 2011)	2.3	> 0.2
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)						
Family Physeteridae						
Sperm whale	Physeter macrocephalus	California/ Oregon/ Washington	E/D; Y	1,967 (0.57, 1,270, 2014)	2.5	0.9
Family Kogiidae						
Pygmy sperm whale	Kogia breviceps	California/ Oregon/ Washington	-/-; N	4,111 (1.12, 1,924, 2014)	19	0

Dwarf sperm whale	Kogia sima	California/ Oregon/ Washington	-/-; N	Unknown (Unknown, Unknown, 2014)	Undetermined	0
Family Ziphiidae (beaked whales)						
Cuvier's beaked whale	Ziphius cavirostris	California/ Oregon/ Washington	-/-; N	3,274 (0.67, 2,059, 2014)	21	< 0.1
Baird's beaked whale	Berardius bairdii	California/ Oregon/ Washington	-/-; N	2,697 (0.6, 1,633, 2014)	16	0
Blainville's beaked whale	Mesoplodon densirostris	California/ Oregon/ Washington	-/-; N	3,044 (0.54, 1,967, 2014)	20	0.1
Hubbs' beaked whale	Mesoplodon carlshubbi					
Stejneger's beaked whale	Mesoplodon stejnegeri					
Family Delphinidae						
Bottlenose dolphin	Tursiops truncatus	California/ Oregon/ Washington offshore	-/-; N	1,924 (0.54, 1,255, 2014)	11	> 1.6
Striped dolphin	Stenella coeruleoalba	California/ Oregon/ Washington	-/-; N	29,211 (0.2, 24,782, 2014)	238	> 0.8
Short-beaked common dolphin	Delphinus delphis	California/ Oregon/ Washington	-/-; N	969,861 (0.17, 839,325, 2014)	8,393	> 40
Pacific white-sided dolphin	Lagenorhynchus obliquidens	California/ Oregon/ Washington	-/-; N	26,814 (0.28, 21,195, 2014)	191	7.5
Northern right whale dolphin	Lissodelphis borealis	California/ Oregon/ Washington	-/-; N	26,556 (0.44, 18,608, 2014)	179	3.8
Risso's dolphin	Grampus griseus	California/ Oregon/ Washington	-/-; N	6,336 (0.32, 4,817, 2014)	46	> 3.7
False killer whale	Pseudorca crassidens	Hawaii Pelagic	-/-; N	1,540 (0.66, 928, 2010)	9.3	7.6
Killer whale	Orcinus orca	Offshore	-/-; N	240 (0.49, 162, 2014)	1.6	0

		Southern Resident	E/D; Y	83 (N/A, 83, 2016)	0.14	0
		Northern Resident	-/-; N	261 (N/A, 261, 2011)	1.96	0
		West Coast Transient	-/-; N	243 (N/A, 243, 2009)	2.4	0
Short-finned pilot whale	Globicephala macrorhynchus	California/ Oregon/ Washington	-/-; N	836 (0.79, 466, 2014)	4.5	1.2
Family Phocoenidae (porpoises)						
Harbor porpoise	Phocoena phocoena	Northern Oregon/Washington Coast	-/-; N	21,487 (0.44, 15,123, 2011)	151	> 3.0
Dall's porpoise	Phocoenoides dalli	California/ Oregon/ Washington	-/-; N	25,750 (0.45, 17,954, 2014)	172	0.3
Order Carnivora – Superfamily Pinnipedia						
Family Otariidae (eared seals and sea lions)						
Northern fur seal	Callorhinus ursinus	Eastern Pacific	- /D; Y	620,660 (0.2, 525,333, 2016)	11,295	457
		California	- /D; N	14,050 (N/A, 7,524, 2013)	451	1.8
California sea lion	Zalophus californianus	U.S.	-/-; N	257,606 (N/A, 233,515, 2014)	14,011	> 197
Steller sea lion	Eumetopias jubatus	Eastern U.S.	-/-; N	41,638 (see SAR, 41,638, 2015)	2,498	108
Guadalupe fur seal	Arctocephalus townsendi	Mexico	T/D; Y	20,000 (N/A, 15,830, 2010)	542	> 3.2
Family Phocidae (earless seals)						
Harbor seal	Phoca vitulina	Oregon/Washington Coastal	-/-; N	Unknown (Unknown, Unknown, 1999)	Undetermined	10.6
Northern elephant seal	Mirounga angustirostris	California Breeding	-/-; N	179,000 (N/A, 81,368, 2010)	4,882	8.8

All species that could potentially occur in the proposed survey areas are included in Table 1. However, the temporal and/or spatial occurrence of gray whales, Southern Resident and Northern Resident killer whales, harbor porpoise, harbor seal, California sea lion, and Steller sea lion is such that take is not expected to occur, and they are not discussed further beyond the explanation provided here. These species are found in the eastern North Pacific, but are generally found in coastal waters and are not expected to occur offshore in the survey area.

Humpback Whale

The humpback whale is found throughout all of the oceans of the world (Clapham 2009). The worldwide population of humpbacks is divided into northern and southern ocean populations, but genetic analyses suggest some gene flow (either past or present) between the North and South Pacific (*e.g.*, Baker *et al.* 1993; Caballero *et al.* 2001). Geographical overlap of these populations has been documented only off Central America (Acevedo and Smultea 1995; Rasmussen *et al.* 2004, 2007). Although considered to be mainly a coastal species, humpback whales often traverse deep pelagic areas while migrating (Clapham and Mattila 1990; Norris *et al.* 1999; Calambokidis *et al.* 2001).

Humpback whales migrate between summer feeding grounds in high latitudes and winter calving and breeding grounds in tropical waters (Clapham and Mead 1999). North Pacific humpback whales summer in feeding grounds along the Pacific Rim and in the Bering and

Okhotsk seas (Pike and MacAskie 1969; Rice 1978; Winn and Reichley 1985; Calambokidis *et al.* 2000, 2001, 2008). Humpbacks winter in four different breeding areas: (1) along the coast of Mexico; (2) along the coast of Central America; (3) around the main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Calambokidis *et al.* 2008; Bettridge *et al.* 2015). These breeding areas have been designated as DPSs, but feeding areas have no DPS status (Bettridge *et al.* 2015; NMFS 2016b). Individuals encountered in the proposed survey area most likely would come from the Central America and Mexico distinct population segments (DPSs), although some individuals from the Hawaii DPS may also feed in these waters. There is a low level of interchange of whales among the main wintering areas and among feeding areas (*e.g.*, Darling and Cerchio 1993; Salden *et al.* 1999; Calambokidis *et al.* 2001, 2008).

The humpback whale is the most common species of large cetacean reported off the coasts of Oregon and Washington from May to November (Green *et al.* 1992; Calambokidis *et al.* 2000, 2004). The highest numbers have been reported off Oregon during May and June and off Washington during July–September. However, off Oregon and Washington, humpbacks occur primarily over the continental shelf and slope during the summer, with few reported in offshore pelagic waters (Green *et al.* 1992; Calambokidis *et al.* 2004, 2015; Becker *et al.* 2012; Menza *et al.* 2016). Biologically important areas (BIAs) for feeding humpback whales along the coasts of Oregon and Washington, which have been designated from May to November, are all within ~80 km offshore (Calambokidis *et al.* 2015).

Minke Whale

The minke whale has a cosmopolitan distribution that spans from tropical to polar regions in both hemispheres (Jefferson *et al.* 2015). In the Northern Hemisphere, the minke whale is

usually seen in coastal areas, but can also be seen in pelagic waters during its northward migration in spring and summer and southward migration in autumn (Stewart and Leatherwood 1985). In the North Pacific, the summer range of the minke whale extends to the Chukchi Sea; in the winter, the whales move farther south to within 2º of the Equator (Perrin and Brownell 2009).

The International Whaling Commission (IWC) recognizes three stocks of minke whales in the North Pacific: the Sea of Japan/East China Sea, the rest of the western Pacific west of 180ºN, and the remainder of the Pacific (Donovan 1991). Minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Brueggeman *et al.* 1990). In the far north, minke whales are thought to be migratory, but they are believed to be year-round residents in coastal waters off the U.S. West Coast (Dorsey *et al.* 1990).

Sei Whale

The distribution of the sei whale is not well known, but it is found in all oceans and appears to prefer mid-latitude temperate waters (Jefferson *et al.* 2015). The sei whale is pelagic and generally not found in coastal waters (Jefferson *et al.* 2015). It is found in deeper waters characteristic of the continental shelf edge region (Hain *et al.* 1985) and in other regions of steep bathymetric relief such as seamounts and canyons (Kenney and Winn 1987; Gregr and Trites 2001). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry *et al.* 1999a). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). During summer in the North Pacific, the sei whale can be found from the Bering Sea to the Gulf of Alaska and down to southern California, as well as in the

western Pacific from Japan to Korea. Its winter distribution is concentrated at ~20° N (Rice 1998).

Fin Whale

The fin whale is widely distributed in all the world's oceans (Gambell 1985b), but typically occurs in temperate and polar regions from 20–70° north and south of the Equator (Perry *et al.* 1999b). Northern and southern fin whale populations are distinct and are sometimes recognized as different subspecies (Aguilar 2009). Fin whales occur in coastal, shelf, and oceanic waters. Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily or because biological productivity is high along steep contours because of tidal mixing and perhaps current mixing. Stafford *et al.* (2009) noted that sea-surface temperature is a good predictor variable for fin whale call detections in the North Pacific.

Fin whales appear to have complex seasonal movements and are seasonal migrants; they mate and calve in temperate waters during the winter and migrate to feed at northern latitudes during the summer (Gambell 1985b). The North Pacific population summers from the Chukchi Sea to California and winters from California southwards (Gambell 1985b). Aggregations of fin whales are found year-round off southern and central California (Dohl *et al.* 1980, 1983; Forney *et al.* 1995; Barlow 1997) and in the summer off Oregon (Green *et al.* 1992; Edwards *et al.* 2015). Vocalizations from fin whales have also been detected year-round off northern California, Oregon, and Washington (Moore *et al.* 1998, 2006; Watkins *et al.* 2000a,b; Stafford *et al.* 2007, 2009; Edwards *et al.* 2015).

Blue Whale

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson *et al.* 2015). Although it has been suggested

that there are at least five subpopulations of blue whales in the North Pacific (NMFS 1998), analysis of blue whale calls monitored from the U.S. Navy Sound Surveillance System (SOSUS) and other offshore hydrophones (see Stafford *et al.* 1999, 2001, 2007; Watkins *et al.* 2000a; Stafford 2003) suggests that there are two separate populations: one in the eastern and one in the western North Pacific (Sears and Perrin 2009). Broad-scale acoustic monitoring indicates that blue whales occurring in the northeast Pacific during summer and fall may winter in the eastern tropical Pacific (Stafford *et al.* 1999, 2001).

The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). The eastern North Pacific stock feeds in California waters from June–November (Calambokidis *et al.* 1990; Mate *et al.* 1999). There are nine BIAs for feeding blue whales off the coast of California (Calambokidis *et al.* 2015), and core areas have also been identified there (Irvine *et al.* 2014). Blue whales have been detected acoustically off Oregon (McDonald *et al.* 1995; Stafford *et al.* 1998; Von Saunder and Barlow 1999), but sightings are uncommon (Carretta *et al.* 2018). Densities along the U.S. West Coast, including Oregon, were predicted to be highest in shelf waters, with lower densities in deeper offshore areas (Becker *et al.* 2012; Calambokidis *et al.* 2015). Buchanan *et al.* (2001) considered blue whales to be rare off Oregon and Washington. However, based on the absolute dynamic topography of the region, blue whales could occur in relatively high densities off Oregon during July–December (Pardo *et al.* 2015).

Sperm Whale

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution (Rice 1989). Sperm whale distribution is linked to social structure: mixed groups of

adult females and juvenile animals of both sexes generally occur in tropical and subtropical waters, whereas adult males are commonly found alone or in same-sex aggregations, often occurring in higher latitudes outside the breeding season (Best 1979; Watkins and Moore 1982; Arnbom and Whitehead 1989; Whitehead and Waters 1990). Males can migrate north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988). Mature male sperm whales migrate to warmer waters to breed when they are in their late twenties (Best 1979).

Sperm whales generally are distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996; Whitehead 2009). They are often found far from shore, but can be found closer to oceanic islands that rise steeply from deep ocean waters (Whitehead 2009). Adult males can occur in water depths <100 m and as shallow as 40 m (Whitehead *et al.* 1992; Scott and Sadove 1997). They can dive as deep as ~2 km and possibly deeper on rare occasions for periods of over 1 h; however, most of their foraging occurs at depths of ~300–800 m for 30–45 min (Whitehead 2003).

Sperm whales are distributed widely across the North Pacific (Rice 1989). Off California, they occur year-round (Dohl *et al.* 1983; Barlow 1995; Forney *et al.* 1995), with peak abundance from April to mid-June and from August to mid-November (Rice 1974). Off Oregon, sperm whales are seen in every season except winter (Green *et al.* 1992).

Oleson *et al.* (2009) noted a significant diel pattern in the occurrence of sperm whale clicks at offshore and inshore monitoring locations off Washington, whereby clicks were more commonly heard during the day at the offshore site and were more common at night at the inshore location, suggesting possible diel movements up and down the slope in search of prey.

Sperm whale acoustic detections were also reported at the inshore site from June through January 2009, with an absence of calls during February to May (Širović *et al.* 2012). In addition, sperm whales were sighted during surveys off Washington in June 2011 and off Oregon in October 2011 (Adams *et al.* 2014).

Pygmy and Dwarf Sperm Whales

The pygmy and dwarf sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown as most information on these species comes from strandings (McAlpine 2009). They are difficult to sight at sea, perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig *et al.* 1998). The two species are difficult to distinguish from one another when sighted (McAlpine 2009).

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen *et al.* 1994; Davis *et al.* 1998). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang *et al.* 2002; MacLeod *et al.* 2004). Barros *et al.* (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié *et al.* 1998).

Cuvier's Beaked Whale

Cuvier's beaked whale is probably the most widespread of the beaked whales, although it is not found in polar waters (Heyning 1989). Cuvier's beaked whale appears to prefer steep continental slope waters (Jefferson *et al.* 2015) and is most common in water depths >1000 m (Heyning 1989). It is mostly known from strandings and strands more commonly than any other beaked whale (Heyning 1989). Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels all help to explain the infrequent sightings (Barlow and Gisiner 2006). The population in the California Current Large Marine Ecosystem seems to be declining (Moore and Barlow 2013).

MacLeod *et al.* (2006) reported numerous sightings and strandings along the Pacific coast of the U.S. Cuvier's beaked whale is the most common beaked whale off the U.S. West Coast (Barlow 2010), and it is the beaked whale species that has stranded most frequently on the coasts of Oregon and Washington. From 1942–2010, there were 23 reported Cuvier's beaked whale strandings in Oregon and Washington (Moore and Barlow 2013). Most (75 percent) Cuvier's beaked whale strandings reported occurred in Oregon (Norman *et al.* 2004).

Blainville's Beaked Whale

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans (Pitman 2009). It has the widest distribution throughout the world of all mesoplodont species and appears to be relatively common (Pitman 2009). Like other beaked whales, Blainville's beaked whale is generally found in waters 200–1400 m deep (Gannier 2000; Jefferson *et al.* 2015). Occasional occurrences in cooler, higher-latitude waters are presumably related to warm-water incursions (Reeves *et al.* 2002). MacLeod *et al.* (2006) reported stranding and sighting records in the eastern Pacific ranging from 37.3° N to 41.5° S. However, none of the 36 beaked whale stranding records in Oregon and Washington during 1930–2002 included Blainville's beaked

whale (Norman *et al.* 2004). One Blainville's beaked whale was found stranded (dead) on the Washington coast in November 2016 (COASST 2016).

Stejneger's Beaked Whale

Stejneger's beaked whale occurs in subarctic and cool temperate waters of the North Pacific Ocean (Mead 1989). In the eastern North Pacific Ocean, it is distributed from Alaska to southern California (Mead *et al.* 1982; Mead 1989). Most stranding records are from Alaskan waters, and the Aleutian Islands appear to be its center of distribution (MacLeod *et al.* 2006). After Cuvier's beaked whale, Stejneger's beaked whale was the second most commonly stranded beaked whale species in Oregon and Washington (Norman *et al.* 2004).

Hubb's Beaked Whale

Hubbs' beaked whale occurs in temperate waters of the North Pacific (Mead 1989). Its distribution appears to be correlated with the deep subarctic current (Mead *et al.* 1982). Numerous stranding records have been reported for the U.S. West Coast (MacLeod *et al.* 2006). Most of the records are from California, but it has been sighted as far north as Prince Rupert, British Columbia (Mead 1989). Two strandings are known from Washington/Oregon (Norman *et al.* 2004). Hubbs' beaked whales are often killed in drift gillnets off California (Reeves *et al.* 2002).

There are no sightings of Hubbs' beaked whales near the proposed survey area in the OBIS database (OBIS 2018). There is one sighting of an unidentified species of *Mesoplodont* whale near the survey area in the OBIS database that was made in July 1996 during the SWFSC ORCAWALE Marine Mammal Survey (OBIS 2018). During the 2016 SWFSC PASCAL study using drifting acoustic recorders, detections were made of beaked whale sounds presumed to be from Hubbs' beaked whales near the proposed survey area during August (Griffiths *et al.*

submitted manuscript cited in Keating *et al.* 2018). In addition, at least two sightings just to the south of the proposed survey area were reported in Carretta *et al.* (2018). This species seems to be less common in the proposed survey area than some of the other beaked whales.

Baird's Beaked Whale

Baird's beaked whale has a fairly extensive range across the North Pacific, with concentrations occurring in the Sea of Okhotsk and Bering Sea (Rice 1998; Kasuya 2009). In the eastern Pacific, Baird's beaked whale is reported to occur as far south as San Clemente Island, California (Rice 1998; Kasuya 2009). Baird's beaked whales that occur off the U.S. west coast are of the gray form, unlike some *Berardius* individuals that are found in Alaska and Japan, which are of the black form and thus could be a new species (Morin *et al.*, 2017).

Bottlenose Dolphin

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson *et al.* 2015). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield *et al.* 1983; Hoelzel *et al.* 1998; Walker *et al.* 1999). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2009).

Short-beaked Common Dolphin

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Perrin 2009). It ranges as far south as 40° S in the Pacific Ocean, is common in coastal waters 200–300 m deep and is also associated with prominent underwater topography,

such as seamounts (Evans 1994). Short-beaked common dolphins have been sighted as far as 550 km from shore (Barlow *et al.* 1997).

The distribution of short-beaked common dolphins along the U.S. West Coast is variable and likely related to oceanographic changes (Heyning and Perrin 1994; Forney and Barlow 1998). It is the most abundant cetacean off California; some sightings have been made off Oregon, in offshore waters (Carretta *et al.* 2017). During surveys off the west coast in 2014 and 2017, sightings were made as far north as 44° N (Barlow 2016; SIO n.d.). Based on the absolute dynamic topography of the region, short-beaked common dolphins could occur in relatively high densities off Oregon during July–December (Pardo *et al.* 2015). In contrast, habitat modeling predicted moderate densities of common dolphins off the Columbia River mouth during summer, with lower densities off southern Oregon (Becker *et al.* 2014).

Striped Dolphin

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters (Perrin *et al.* 1994) and is generally seen south of 43º N (Archer 2009). However, in the eastern North Pacific, its distribution extends as far north as Washington (Jefferson *et al.* 2015). The striped dolphin is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling (Archer 2009). However, it has also been observed approaching shore where there is deep water close to the coast (Jefferson *et al.* 2015).

Pacific White-sided Dolphin

The Pacific white-sided dolphin is found in cool temperate waters of the North Pacific from the southern Gulf of California to Alaska. Across the North Pacific, it appears to have a relatively narrow distribution between 38° N and 47° N (Brownell *et al.* 1999). In the eastern North Pacific Ocean, including waters off Oregon, the Pacific white-sided dolphin is one of the

most common cetacean species, occurring primarily in shelf and slope waters (Green *et al.* 1993; Barlow 2003, 2010). It is known to occur close to shore in certain regions, including (seasonally) southern California (Brownell *et al.* 1999).

Results of aerial and shipboard surveys strongly suggest seasonal north–south movements of the species between California and Oregon/Washington; the movements apparently are related to oceanographic influences, particularly water temperature (Green *et al.* 1993; Forney and Barlow 1998; Buchanan *et al.* 2001). During winter, this species is most abundant in California slope and offshore areas; as northern waters begin to warm in the spring, it appears to move north to slope and offshore waters off Oregon/Washington (Green *et al.* 1992, 1993; Forney 1994; Forney *et al.* 1995; Buchanan *et al.* 2001; Barlow 2003). The highest encounter rates off Oregon and Washington have been reported during March–May in slope and offshore waters (Green *et al.* 1992). Similarly, Becker *et al.* (2014) predicted relatively high densities off southern Oregon in shelf and slope waters.

Based on year-round aerial surveys off Oregon/Washington, the Pacific white-sided dolphin was the most abundant cetacean species, with nearly all (97 percent) sightings occurring in May (Green *et al.* 1992, 1993). Barlow (2003) also found that the Pacific white-sided dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996 and 2001 ship surveys, and it was the second most abundant species reported during 2008 surveys (Barlow 2010). Adams *et al.* (2014) reported numerous offshore sightings off Oregon during summer, fall, and winter surveys in 2011 and 2012. Based on surveys conducted during 2014, the abundance was estimated at 20,711 for Oregon/Washington (Barlow 2016).

Northern Right Whale Dolphin

The northern right whale dolphin is found in cool temperate and sub-arctic waters of the North Pacific, from the Gulf of Alaska to near northern Baja California, ranging from 30° N to 50° N (Reeves *et al.* 2002). In the eastern North Pacific Ocean, including waters off Oregon, the northern right whale dolphin is one of the most common marine mammal species, occurring primarily in shelf and slope waters ~100 to >2000 m deep (Green *et al.* 1993; Barlow 2003). The northern right whale dolphin comes closer to shore where there is deep water, such as over submarine canyons (Reeves *et al.* 2002).

Aerial and shipboard surveys suggest seasonal inshore–offshore and north–south movements in the eastern North Pacific Ocean between California and Oregon/Washington; the movements are believed to be related to oceanographic influences, particularly water temperature and presumably prey distribution and availability (Green *et al.* 1993; Forney and Barlow 1998; Buchanan *et al.* 2001). Green *et al.* (1992, 1993) found that northern right whale dolphins were most abundant off Oregon/Washington during fall, less abundant during spring and summer, and absent during winter, when this species presumably moves south to warmer California waters (Green *et al.* 1992, 1993; Forney 1994; Forney *et al.* 1995; Buchanan *et al.* 2001; Barlow 2003). Considerable interannual variations in abundance also have been found.

Becker *et al.* (2014) predicted relatively high densities off southern Oregon, and moderate densities off northern Oregon and Washington. Based on year-round aerial surveys off Oregon/Washington, the northern right whale dolphin was the third most abundant cetacean species, concentrated in slope waters but also occurring in water out to ~550 km offshore (Green *et al.* 1992, 1993). Barlow (2003, 2010) also found that the northern right whale dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996, 2001, 2005,

and 2008 ship surveys. Offshore sightings were made in the waters of Oregon during summer, fall, and winter surveys in 2011 and 2012 (Adams *et al.* 2014).

Risso's Dolphin

Risso's dolphin is distributed worldwide in temperate and tropical oceans (Baird 2009), although it shows a preference for mid-temperate waters of the shelf and slope between 30□ and 45□ (Jefferson *et al.* 2014). Although it is known to occur in coastal and oceanic habitats (Jefferson *et al.* 2014), it appears to prefer steep sections of the continental shelf, 400–1000 m deep (Baird 2009), and is known to frequent seamounts and escarpments (Kruse *et al.* 1999). Off the U.S. West Coast, Risso's dolphin is believed to make seasonal north-south movements related to water temperature, spending colder winter months off California and moving north to waters off Oregon/Washington during the spring and summer as northern waters begin to warm (Green *et al.* 1992, 1993; Buchanan *et al.* 2001; Barlow 2003; Becker 2007).

The distribution and abundance of Risso's dolphins are highly variable from California to Washington, presumably in response to changing oceanographic conditions on both annual and seasonal time scales (Forney and Barlow 1998; Buchanan *et al.* 2001). The highest densities were predicted along the coasts of Washington, Oregon, and central and southern California (Becker *et al.* 2012). Off Oregon and Washington, Risso's dolphins are most abundant over continental slope and shelf waters during spring and summer, less so during fall, and rare during winter (Green *et al.* 1992, 1993). Green *et al.* (1992, 1993) reported most Risso's dolphin groups off Oregon between ~45 and 47º N. Several sightings were made off southern Oregon during surveys in 1991–2014 (Carretta *et al.* 2017). Sightings during ship surveys in summer/fall 2008 were mostly between ~30 and 38º N; none were reported in Oregon/Washington (Barlow 2010).

Based on 2014 survey data, the abundance for Oregon/Washington was estimated at 430 (Barlow 2016).

False Killer Whale

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep, offshore waters (Odell and McClune 1999). However, it is also known to occur in nearshore areas (*e.g.*, Stacey and Baird 1991). In the eastern North Pacific, it has been reported only rarely north of Baja California (Leatherwood *et al.* 1982, 1987; Mangels and Gerrodette 1994); however, the waters off the U.S. West Coast all the way north to Alaska are considered part of its secondary range (Jefferson *et al.* 2015). Its occurrence in Washington/Oregon is associated with warm-water incursions (Buchanan *et al.* 2001). One pod of false killer whales occurred in Puget Sound for several months during the 1990s (USN 2015). Two were reported stranded along the Washington coast during 1930–2002, both in El Niño years (Norman *et al.* 2004). One sighting was made off southern California during 2014 (Barlow 2016).

Killer Whale

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). Currently, there are eight killer whale stocks recognized in the U.S. Pacific: (1) Alaska Residents, occurring from southeast Alaska to the Aleutians and Bering Sea; (2) Northern Residents, from BC through parts of southeast Alaska; (3) Southern Residents, mainly in inland waters of Washington State and southern BC; (4) Gulf of Alaska, Aleutians, and Bering Sea Transients, from Prince William Sound (PWS) through to the Aleutians and Bering Sea; (5) AT1 Transients, from PWS through the Kenai Fjords; (6) West Coast Transients, from California through southeast Alaska; (7)

Offshore, from California through Alaska; and (8) Hawaiian (Carretta *et al.* 2018). Individuals from the Offshore and West Coast Transient stocks could be encountered in the proposed project area.

Green *et al.* (1992) noted that most groups seen during their surveys off Oregon and Washington were likely transients; during those surveys, killer whales were sighted only in shelf waters. Killer whales were sighted off Washington in July and September 2012 (Adams *et al.* 2014). Two of 17 killer whales that stranded in Oregon were confirmed as transient (Stevens *et al.* 1989 *in* Norman *et al.* 2004).

Short-finned Pilot Whale

The short-finned pilot whale is found in tropical, subtropical, and warm temperate waters (Olson 2009); it is seen as far south as ~40º S and as far north as ~50º N (Jefferson *et al.* 2015). Pilot whales are generally nomadic, but may be resident in certain locations, including California and Hawaii (Olson 2009). Short-finned pilot whales were common off southern California (Dohl *et al.* 1980) until an El Niño event occurred in 1982–1983 (Carretta *et al.* 2017).

Dall's Porpoise

Dall's porpoise is found in temperate to subantarctic waters of the North Pacific and adjacent seas (Jefferson *et al.* 2015). It is widely distributed across the North Pacific over the continental shelf and slope waters, and over deep (>2500 m) oceanic waters (Hall 1979). It is probably the most abundant small cetacean in the North Pacific Ocean, and its abundance changes seasonally, likely in relation to water temperature (Becker 2007).

Off Oregon and Washington, Dall's porpoise is widely distributed over shelf and slope waters, with concentrations near shelf edges, but is also commonly sighted in pelagic offshore waters (Morejohn 1979; Green *et al.* 1992; Becker *et al.* 2014; Carretta *et al.* 2018). Combined

results of various surveys out to ~550 km offshore indicate that the distribution and abundance of Dall's porpoise varies between seasons and years. North–south movements are believed to occur between Oregon/Washington and California in response to changing oceanographic conditions, particularly temperature and distribution and abundance of prey (Green *et al.* 1992, 1993; Mangels and Gerrodette 1994; Barlow 1995; Forney and Barlow 1998; Buchanan *et al.* 2001). Becker *et al.* (2014) predicted high densities off southern Oregon throughout the year, with moderate densities to the north. According to predictive density distribution maps, the highest densities off southern Washington and Oregon occur along the 500-m isobath (Menza *et al.* 2016).

Encounter rates reported by Green *et al.* (1992) during aerial surveys off Oregon/Washington were highest in fall, lowest during winter, and intermediate during spring and summer. Encounter rates during the summer were similarly high in slope and shelf waters, and somewhat lower in offshore waters (Green *et al.* 1992). Dall's porpoise was the most abundant species sighted off Oregon/Washington during 1996, 2001, 2005, and 2008 ship surveys up to ~550 km from shore (Barlow 2003, 2010).

Northern Fur Seal

The northern fur seal is endemic to the North Pacific Ocean and occurs from southern California to the Bering Sea, Sea of Okhotsk, and Sea of Japan (Jefferson *et al.* 2015). The worldwide population of northern fur seals has declined substantially from 1.8 million animals in the 1950s (Muto *et al.* 2018). They were subjected to large-scale harvests on the Pribilof Islands to supply a lucrative fur trade. Two stocks are recognized in U.S. waters: the Eastern North Pacific and the California stocks. The Eastern Pacific stock ranges from southern California during winter to the Pribilof Islands and Bogoslof Island in the Bering Sea during summer

(Carretta *et al.* 2018; Muto *et al.* 2018). Abundance of the Eastern Pacific Stock has been decreasing at the Pribilof Islands since the 1940s and increasing on Bogoslof Island.

Most northern fur seals are highly migratory. During the breeding season, most of the world's population of northern fur seals occurs on the Pribilof and Bogoslof islands (NMFS 2007). The main breeding season is in July (Gentry 2009). Adult males usually occur onshore from May to August, though some may be present until November; females are usually found ashore from June to November (Muto *et al.* 2018). Nearly all fur seals from the Pribilof Island rookeries are foraging at sea from fall through late spring. In November, females and pups leave the Pribilof Islands and migrate through the Gulf of Alaska to feeding areas primarily off the coasts of BC, Washington, Oregon, and California before migrating north again to the rookeries in spring (Ream *et al.* 2005; Pelland *et al.* 2014). Immature seals can remain in southern foraging areas year-round until they are old enough to mate (NMFS 2007). Adult males migrate only as far south as the Gulf of Alaska or to the west off the Kuril Islands (Kajimura 1984). Pups from the California stock also migrate to Washington, Oregon, and northern California after weaning (Lea *et al.* 2009).

The northern fur seals spends ~90 percent of its time at sea, typically in areas of upwelling along the continental slopes and over seamounts (Gentry 1981). The remainder of its life is spent on or near rookery islands or haulouts. While at sea, northern fur seals usually occur singly or in pairs, although larger groups can form in waters rich with prey (Antonelis and Fiscus 1980; Gentry 1981). Northern fur seals dive to relatively shallow depths to feed: 100–200 m for females, and <400 m for males (Gentry 2009). Tagged adult female fur seals were shown to remain within 200 km of the shelf break (Pelland *et al.* 2014).

Bonnell *et al.* (1992) noted the presence of northern fur seals year-round off Oregon/Washington, with the greatest numbers (87 percent) occurring in January–May. Northern fur seals were seen as far out from the coast as 185 km, and numbers increased with distance from land; they were 5–6 times more abundant in offshore waters than over the shelf or slope (Bonnell *et al.* 1992). The highest densities were seen in the Columbia River plume (~46° N) and in deep offshore waters (>2000 m) off central and southern Oregon (Bonnell *et al.* 1992). The waters off Washington are a known foraging area for adult females, and concentrations of fur seals were also reported to occur near Cape Blanco, Oregon, at ~42.8° N (Pelland *et al.* 2014). Tagged adult fur seals were tracked from the Pribilof Islands to the waters off Washington/Oregon/California, with recorded movement throughout the proposed project area (Pelland *et al.* 2014).

Guadalupe Fur Seal

Guadalupe fur seals were once plentiful on the California coast, ranging from the Gulf of the Farallones near San Francisco, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa *et al.*, 1999), but they were over-harvested in the 19th century to near extinction. After being protected, the population grew slowly; mature individuals of the species were observed occasionally in the Southern California Bight starting in the 1960s (Stewart *et al.*, 1993), and, in 1997, a female and pup were observed on San Miguel Island (Melin & DeLong, 1999). Since then, a small group has persisted in that area (Aurioles-Gamboa *et al.*, 2010).

The distribution of Guadalupe fur seals and occurrence in the survey area is dependent on life stage and season. During the breeding season, June through August, adult males are expected to be on shore on Guadalupe Island and at smaller rookeries in the San Benito archipelago (Carretta *et al.*, 2017b; Norris, 2017b). No satellite telemetry data are available for adult males;

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however, following the breeding season most adult males are expected to move north of breeding grounds to forage.

From 2015 through 2017, 26 stranded and rehabilitated fur seals between the ages of 11 and 15 months were released with satellite tags in central California. These animals frequently migrated north of Point Cabrillo and several moved into waters as far north as British Columbia, Canada. However, it is unclear if the migratory patterns of rehabilitated and released fur seals are representative of the free-ranging population migrating north from Guadalupe Island. For example, the rehabilitated fur seals remained closer to shore than the free-ranging fur seals as they migrated north (Norris, 2017b).

The satellite telemetry data indicate that Guadalupe fur seals more than two years old are likely uncommon in the survey area, but a majority of fur seals under two years old may migrate into the survey area and may be present throughout the year (Norris, 2017b). Lambourn *et al.* (2012) described an unusual mortality event during which 29 Guadalupe fur seals were reported stranded throughout the Pacific Northwest from 2007 to 2009. The strandings involved one live adult female and 28 dead yearlings of both sexes. The stranding data support the more recent telemetry data indicating that fur seals less than 2 years of age are more likely to occur in the survey area than older fur seals.

Northern Elephant Seal

The northern elephant seal breeds in California and Baja California, primarily on offshore islands, from Cedros off the west coast of Baja California, north to the Farallons in Central California (Stewart *et al.* 1994). Pupping has also been observed at Shell Island (~43.3° N) off southern Oregon, suggesting a range expansion (Bonnell *et al.* 1992; Hodder *et al.* 1998).

Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt (Stewart and DeLong 1995). Between the two foraging periods, they return to land to molt, with females returning earlier than males (March–April vs. July–August). After the molt, adults then return to their northern feeding areas until the next winter breeding season. Breeding occurs from December to March (Stewart and Huber 1993). Females arrive in late December or January and give birth within ~1 week of their arrival. Pups are weaned after just 27 days and are abandoned by their mothers. Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 900–1000 km. Hindell (2009) noted that traveling likely takes place at depths >200 m. Most elephant seals return to their natal rookeries when they start breeding (Huber *et al.* 1991).

When not at their breeding rookeries, adults feed at sea far from the rookeries. Males may feed as far north as the eastern Aleutian Islands and the Gulf of Alaska, whereas females feed south of 45º N (Le Boeuf *et al.* 1993; Stewart and Huber 1993). Adult male elephant seals migrate north via the California current to the Gulf of Alaska during foraging trips, and could potentially be passing through the area off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods), but likely their presence there is transient and short-lived. Adult females and juveniles forage in the California current off California to BC (Le Boeuf *et al.* 1986, 1993, 2000). Bonnell *et al.* (1992) reported that northern elephant seals were distributed equally in shelf, slope, and offshore waters during surveys conducted off Oregon and Washington, as far as 150 km from shore, in waters >2000 m deep. Telemetry data indicate that they range much farther offshore than that (Stewart and DeLong 1995).

Marine Mammal Hearing

Hearing is the most important sensory modality for marine mammals underwater, and exposure to anthropogenic sound can have deleterious effects. To appropriately assess the potential effects of exposure to sound, it is necessary to understand the frequency ranges marine mammals are able to hear. Current data indicate that not all marine mammal species have equal hearing capabilities (*e.g.*, Richardson *et al.*, 1995; Wartzok and Ketten, 1999; Au and Hastings, 2008). To reflect this, Southall *et al.* (2007) recommended that marine mammals be divided into functional hearing groups based on directly measured or estimated hearing ranges on the basis of available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. Note that no direct measurements of hearing ability have been successfully completed for mysticetes (*i.e.*, low-frequency cetaceans). Subsequently, NMFS (2018) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 decibel (dB) threshold from the normalized composite audiograms, with the exception for lower limits for low-frequency cetaceans where the lower bound was deemed to be biologically implausible and the lower bound from Southall *et al.* (2007) retained. Marine mammal hearing groups and their associated hearing ranges are provided in Table 2.

Table 2. Marine Mammal Hearing Groups (NMFS, 2018).

Hearing Group	Generalized Hearing Range*
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz
* Represents the generalized hearing range for the entire group as a composite (*i.e.*, all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall *et al.* 2007) and PW pinniped (approximation).	

The pinniped functional hearing group was modified from Southall *et al.* (2007) on the basis of data indicating that phocid species have consistently demonstrated an extended frequency range of hearing compared to otariids, especially in the higher frequency range (Hemilä *et al.*, 2006; Kastelein *et al.*, 2009; Reichmuth and Holt, 2013).

For more detail concerning these groups and associated frequency ranges, please see NMFS (2018) for a review of available information. 26 marine mammal species (23 cetacean and three pinniped (two otariid and one phocid) species) have the reasonable potential to co-occur with the proposed survey activities. Please refer to Table 1. Of the cetacean species that may be present, five are classified as low-frequency cetaceans (*i.e.*, all mysticete species), 15 are classified as mid-frequency cetaceans (*i.e.*, all delphinid and ziphiid species and the sperm whale), and three are classified as high-frequency cetaceans (*i.e.*, harbor porpoise and Kogia spp.).

Potential Effects of Specified Activities on Marine Mammals and their Habitat

This section includes a summary and discussion of the ways that components of the specified activity may impact marine mammals and their habitat. The *Estimated Take by*

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Incidental Harassment section later in this document includes a quantitative analysis of the number of individuals that are expected to be taken by this activity. The *Negligible Impact Analysis and Determination* section considers the content of this section, the *Estimated Take by Incidental Harassment* section, and the *Proposed Mitigation* section, to draw conclusions regarding the likely impacts of these activities on the reproductive success or survivorship of individuals and how those impacts on individuals are likely to impact marine mammal species or stocks.

Description of Active Acoustic Sound Sources

This section contains a brief technical background on sound, the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant to the specified activity and to a discussion of the potential effects of the specified activity on marine mammals found later in this document.

Sound travels in waves, the basic components of which are frequency, wavelength, velocity, and amplitude. Frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in hertz (Hz) or cycles per second. Wavelength is the distance between two peaks or corresponding points of a sound wave (length of one cycle). Higher frequency sounds have shorter wavelengths than lower frequency sounds, and typically attenuate (decrease) more rapidly, except in certain cases in shallower water. Amplitude is the height of the sound pressure wave or the "loudness" of a sound and is typically described using the relative unit of the dB. A sound pressure level (SPL) in dB is described as the ratio between a measured pressure and a reference pressure (for underwater sound, this is 1 microPascal (μPa)) and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL)

represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa) while the received level is the SPL at the listener's position (referenced to 1 μPa).

Root mean square (rms) is the quadratic mean sound pressure over the duration of an impulse. Root mean square is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). Root mean square accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation of pressure levels (Hastings and Popper, 2005). This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units than by peak pressures.

Sound exposure level (SEL; represented as dB re 1 μPa2−s) represents the total energy contained within a pulse and considers both intensity and duration of exposure. Peak sound pressure (also referred to as zero-to-peak sound pressure or 0-p) is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source and is represented in the same units as the rms sound pressure. Another common metric is peak-to-peak sound pressure (pk-pk), which is the algebraic difference between the peak positive and peak negative sound pressures. Peak-to-peak pressure is typically approximately 6 dB higher than peak pressure (Southall *et al.*, 2007).

When underwater objects vibrate or activity occurs, sound-pressure waves are created. These waves alternately compress and decompress the water as the sound wave travels. Underwater sound waves radiate in a manner similar to ripples on the surface of a pond and may be either directed in a beam or beams or may radiate in all directions (omnidirectional sources), as is the case for pulses produced by the airgun arrays considered here. The compressions and

decompressions associated with sound waves are detected as changes in pressure by aquatic life and man-made sound receptors such as hydrophones.

Even in the absence of sound from the specified activity, the underwater environment is typically loud due to ambient sound. Ambient sound is defined as environmental background sound levels lacking a single source or point (Richardson *et al.*, 1995), and the sound level of a region is defined by the total acoustical energy being generated by known and unknown sources. These sources may include physical (*e.g.*, wind and waves, earthquakes, ice, atmospheric sound), biological (*e.g.*, sounds produced by marine mammals, fish, and invertebrates), and anthropogenic (*e.g.*, vessels, dredging, construction) sound. A number of sources contribute to ambient sound, including the following (Richardson *et al.*, 1995):

- *Wind and waves*: The complex interactions between wind and water surface, including processes such as breaking waves and wave-induced bubble oscillations and cavitation, are a main source of naturally occurring ambient sound for frequencies between 200 Hz and 50 kHz (Mitson, 1995). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Surf sound becomes important near shore, with measurements collected at a distance of 8.5 km from shore showing an increase of 10 dB in the 100 to 700 Hz band during heavy surf conditions;

- *Precipitation*: Sound from rain and hail impacting the water surface can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times;

- *Biological*: Marine mammals can contribute significantly to ambient sound levels, as can some fish and snapping shrimp. The frequency band for biological contributions is from approximately 12 Hz to over 100 kHz; and

- *Anthropogenic*: Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, seismic surveys, sonar, explosions, and ocean acoustic studies. Vessel noise typically dominates the total ambient sound for frequencies between 20 and 300 Hz. In general, the frequencies of anthropogenic sounds are below 1 kHz and, if higher frequency sound levels are created, they attenuate rapidly. Sound from identifiable anthropogenic sources other than the activity of interest (*e.g.*, a passing vessel) is sometimes termed background sound, as opposed to ambient sound.

The sum of the various natural and anthropogenic sound sources at any given location and time—which comprise "ambient" or "background" sound—depends not only on the source levels (as determined by current weather conditions and levels of biological and human activity) but also on the ability of sound to propagate through the environment. In turn, sound propagation is dependent on the spatially and temporally varying properties of the water column and sea floor, and is frequency-dependent. As a result of the dependence on a large number of varying factors, ambient sound levels can be expected to vary widely over both coarse and fine spatial and temporal scales. Sound levels at a given frequency and location can vary by 10-20 dB from day to day (Richardson *et al.*, 1995). The result is that, depending on the source type and its intensity, sound from a given activity may be a negligible addition to the local environment or

could form a distinctive signal that may affect marine mammals. Details of source types are described in the following text.

Sounds are often considered to fall into one of two general types: Pulsed and non-pulsed (defined in the following). The distinction between these two sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (*e.g.*, Ward, 1997 in Southall *et al.*, 2007). Please see Southall *et al.* (2007) for an in-depth discussion of these concepts.

Pulsed sound sources (*e.g.*, airguns, explosions, gunshots, sonic booms, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, atonal transients (ANSI, 1986, 2005; Harris, 1998; NIOSH, 1998; ISO, 2003) and occur either as isolated events or repeated in some succession. Pulsed sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

Non-pulsed sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous (ANSI, 1995; NIOSH, 1998). Some of these non-pulsed sounds can be transient signals of short duration but without the essential properties of pulses (*e.g.*, rapid rise time). Examples of non-pulsed sounds include those produced by vessels, aircraft, machinery operations such as drilling or dredging, vibratory pile driving, and active sonar systems (such as those used by the U.S. Navy). The duration of such sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Airgun arrays produce pulsed signals with energy in a frequency range from about 10-2,000 Hz, with most energy radiated at frequencies below 200 Hz. The amplitude of the acoustic wave emitted from the source is equal in all directions (*i.e.*, omnidirectional), but airgun arrays do possess some directionality due to different phase delays between guns in different directions. Airgun arrays are typically tuned to maximize functionality for data acquisition purposes, meaning that sound transmitted in horizontal directions and at higher frequencies is minimized to the extent possible.

Acoustic Effects

Here, we discuss the effects of active acoustic sources on marine mammals.

Potential Effects of Underwater Sound—Please refer to the information given previously ("Description of Active Acoustic Sources") regarding sound, characteristics of sound types, and metrics used in this document. Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on received levels, duration of exposure, behavioral context, and various other factors. The potential effects of underwater sound from active acoustic sources can potentially result in one or more of the following: Temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson *et al.*, 1995; Gordon *et al.*, 2004; Nowacek *et al.*, 2007; Southall *et al.*, 2007; Götz *et al.*, 2009). The degree of effect is intrinsically related to the signal characteristics, received level, distance from the source, and duration of the sound exposure. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within an

animal's hearing range. We first describe specific manifestations of acoustic effects before providing discussion specific to the use of airgun arrays.

Richardson *et al.* (1995) described zones of increasing intensity of effect that might be expected to occur, in relation to distance from a source and assuming that the signal is within an animal's hearing range. First is the area within which the acoustic signal would be audible (potentially perceived) to the animal, but not strong enough to elicit any overt behavioral or physiological response. The next zone corresponds with the area where the signal is audible to the animal and of sufficient intensity to elicit behavioral or physiological responsiveness. Third is a zone within which, for signals of high intensity, the received level is sufficient to potentially cause discomfort or tissue damage to auditory or other systems. Overlaying these zones to a certain extent is the area within which masking (*i.e.*, when a sound interferes with or masks the ability of an animal to detect a signal of interest that is above the absolute hearing threshold) may occur; the masking zone may be highly variable in size.

We describe the more severe effects of certain non-auditory physical or physiological effects only briefly as we do not expect that use of airgun arrays are reasonably likely to result in such effects (see below for further discussion). Potential effects from impulsive sound sources can range in severity from effects such as behavioral disturbance or tactile perception to physical discomfort, slight injury of the internal organs and the auditory system, or mortality (Yelverton *et al.*, 1973). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to high level underwater sound or as a secondary effect of extreme behavioral reactions (*e.g.*, change in dive profile as a result of an avoidance reaction) caused by exposure to sound include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox *et al.*, 2006; Southall *et al.*, 2007; Zimmer and Tyack,

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2007; Tal *et al.*, 2015). The survey activities considered here do not involve the use of devices such as explosives or mid-frequency tactical sonar that are associated with these types of effects.

Threshold Shift—Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Finneran, 2015). TS can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall *et al.*, 2007). Repeated sound exposure that leads to TTS could cause PTS. In severe cases of PTS, there can be total or partial deafness, while in most cases the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985).

When PTS occurs, there is physical damage to the sound receptors in the ear (*i.e.*, tissue damage), whereas TTS represents primarily tissue fatigue and is reversible (Southall *et al.*, 2007). In addition, other investigators have suggested that TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury (*e.g.*, Ward, 1997). Therefore, NMFS does not consider TTS to constitute auditory injury.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, and there is no PTS data for cetaceans but such relationships are assumed to be similar to those in humans and other terrestrial mammals. PTS typically occurs at exposure levels at least several dBs above (a 40-dB threshold shift approximates PTS onset; *e.g.*, Kryter *et al.*, 1966; Miller, 1974) that inducing mild TTS (a 6-dB threshold shift approximates TTS onset; *e.g.*, Southall *et al.* 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS thresholds for impulse sounds (such as airgun pulses as received close to the source) are at least 6 dB higher than the TTS threshold on a peak-pressure basis and PTS

cumulative sound exposure level thresholds are 15 to 20 dB higher than TTS cumulative sound exposure level thresholds (Southall *et al.*, 2007). Given the higher level of sound or longer exposure duration necessary to cause PTS as compared with TTS, it is considerably less likely that PTS could occur.

For mid-frequency cetaceans in particular, potential protective mechanisms may help limit onset of TTS or prevent onset of PTS. Such mechanisms include dampening of hearing, auditory adaptation, or behavioral amelioration (*e.g.*, Nachtigall and Supin, 2013; Miller *et al.*, 2012; Finneran *et al.*, 2015; Popov *et al.*, 2016).

TTS is the mildest form of hearing impairment that can occur during exposure to sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises, and a sound must be at a higher level in order to be heard. In terrestrial and marine mammals, TTS can last from minutes or hours to days (in cases of strong TTS). In many cases, hearing sensitivity recovers rapidly after exposure to the sound ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals.

Marine mammal hearing plays a critical role in communication with conspecifics, and interpretation of environmental cues for purposes such as predator avoidance and prey capture. Depending on the degree (elevation of threshold in dB), duration (*i.e.*, recovery time), and frequency range of TTS, and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. For example, a marine mammal may be able to readily compensate for a brief, relatively small amount of TTS in a non-critical frequency range that occurs during a time where ambient noise is lower and there are not as many competing sounds present. Alternatively, a larger amount and longer duration of TTS sustained

during time when communication is critical for successful mother/calf interactions could have more serious impacts.

Finneran *et al.* (2015) measured hearing thresholds in three captive bottlenose dolphins before and after exposure to ten pulses produced by a seismic airgun in order to study TTS induced after exposure to multiple pulses. Exposures began at relatively low levels and gradually increased over a period of several months, with the highest exposures at peak SPLs from 196 to 210 dB and cumulative (unweighted) SELs from 193-195 dB. No substantial TTS was observed. In addition, behavioral reactions were observed that indicated that animals can learn behaviors that effectively mitigate noise exposures (although exposure patterns must be learned, which is less likely in wild animals than for the captive animals considered in this study). The authors note that the failure to induce more significant auditory effects likely due to the intermittent nature of exposure, the relatively low peak pressure produced by the acoustic source, and the low-frequency energy in airgun pulses as compared with the frequency range of best sensitivity for dolphins and other mid-frequency cetaceans.

Currently, TTS data only exist for four species of cetaceans (bottlenose dolphin, beluga whale, harbor porpoise, and Yangtze finless porpoise) exposed to a limited number of sound sources (*i.e.*, mostly tones and octave-band noise) in laboratory settings (Finneran, 2015). In general, harbor porpoises have a lower TTS onset than other measured cetacean species (Finneran, 2015). Additionally, the existing marine mammal TTS data come from a limited number of individuals within these species. There are no data available on noise-induced hearing loss for mysticetes.

Critical questions remain regarding the rate of TTS growth and recovery after exposure to intermittent noise and the effects of single and multiple pulses. Data at present are also

insufficient to construct generalized models for recovery and determine the time necessary to treat subsequent exposures as independent events. More information is needed on the relationship between auditory evoked potential and behavioral measures of TTS for various stimuli. For summaries of data on TTS in marine mammals or for further discussion of TTS onset thresholds, please see Southall *et al.* (2007), Finneran and Jenkins (2012), Finneran (2015), and NMFS (2016a).

Behavioral Effects—Behavioral disturbance may include a variety of effects, including subtle changes in behavior (*e.g.*, minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. Behavioral responses to sound are highly variable and context-specific and any reactions depend on numerous intrinsic and extrinsic factors (*e.g.*, species, state of maturity, experience, current activity, reproductive state, auditory sensitivity, time of day), as well as the interplay between factors (*e.g.*, Richardson *et al.*, 1995; Wartzok *et al.*, 2003; Southall *et al.*, 2007; Weilgart, 2007; Archer *et al.*, 2010). Behavioral reactions can vary not only among individuals but also within an individual, depending on previous experience with a sound source, context, and numerous other factors (Ellison *et al.*, 2012), and can vary depending on characteristics associated with the sound source (*e.g.*, whether it is moving or stationary, number of sources, distance from the source). Please see Appendices B-C of Southall *et al.* (2007) for a review of studies involving marine mammal behavioral responses to sound.

Habituation can occur when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok *et al.*, 2003). Animals are most likely to habituate to sounds that are predictable and unvarying. It is important to note

that habituation is appropriately considered as a "progressive reduction in response to stimuli that are perceived as neither aversive nor beneficial," rather than as, more generally, moderation in response to human disturbance (Bejder *et al.*, 2009). The opposite process is sensitization, when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at a lower level of exposure. As noted, behavioral state may affect the type of response. For example, animals that are resting may show greater behavioral change in response to disturbing sound levels than animals that are highly motivated to remain in an area for feeding (Richardson *et al.*, 1995; NRC, 2003; Wartzok *et al.*, 2003). Controlled experiments with captive marine mammals have showed pronounced behavioral reactions, including avoidance of loud sound sources (Ridgway *et al.*, 1997). Observed responses of wild marine mammals to loud pulsed sound sources (typically seismic airguns or acoustic harassment devices) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (Morton and Symonds, 2002; see also Richardson *et al.*, 1995; Nowacek *et al.*, 2007). However, many delphinids approach acoustic source vessels with no apparent discomfort or obvious behavioral change (*e.g.*, Barkaszi *et al.*, 2012).

Available studies show wide variation in response to underwater sound; therefore, it is difficult to predict specifically how any given sound in a particular instance might affect marine mammals perceiving the signal. 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; NRC, 2005). However, there are broad categories of potential response, which

we describe in greater detail here, that include alteration of dive behavior, alteration of foraging behavior, effects to breathing, interference with or alteration of vocalization, avoidance, and flight.

Changes in dive behavior can vary widely, and may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive (*e.g.*, Frankel and Clark, 2000; Ng and Leung, 2003; Nowacek *et al.*, 2004; Goldbogen *et al.*, 2013a, b). Variations in dive behavior may reflect interruptions in biologically significant activities (*e.g.*, foraging) or they may be of little biological significance. The impact of an alteration to dive behavior resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (*e.g.*, bubble nets or sediment plumes), or changes in dive behavior. As for other types of behavioral response, the frequency, duration, and temporal pattern of signal presentation, as well as differences in species sensitivity, are likely contributing factors to differences in response in any given circumstance (*e.g.*, Croll *et al.*, 2001; Nowacek *et al.*; 2004; Madsen *et al.*, 2006; Yazvenko *et al.*, 2007). A determination of whether foraging disruptions incur fitness consequences would require information on or estimates of the energetic requirements of the affected individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Visual tracking, passive acoustic monitoring, and movement recording tags were used to quantify sperm whale behavior prior to, during, and following exposure to airgun arrays at received levels in the range 140-160 dB at distances of 7-13 km, following a phase-in of sound

intensity and full array exposures at 1-13 km (Madsen *et al.*, 2006; Miller *et al.*, 2009). Sperm whales did not exhibit horizontal avoidance behavior at the surface. However, foraging behavior may have been affected. The sperm whales exhibited 19 percent less vocal (buzz) rate during full exposure relative to post exposure, and the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing. The remaining whales continued to execute foraging dives throughout exposure; however, swimming movements during foraging dives were 6 percent lower during exposure than control periods (Miller *et al.*, 2009). These data raise concerns that seismic surveys may impact foraging behavior in sperm whales, although more data are required to understand whether the differences were due to exposure or natural variation in sperm whale behavior (Miller *et al.*, 2009).

Variations in respiration naturally vary with different behaviors and alterations to breathing rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Various studies have shown that respiration rates may either be unaffected or could increase, depending on the species and signal characteristics, again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure (*e.g.*, Kastelein *et al.*, 2001, 2005, 2006; Gailey *et al.*, 2007, 2016).

Marine mammals vocalize for different purposes and across multiple modes, such as whistling, echolocation click production, calling, and singing. Changes in vocalization behavior in response to anthropogenic noise can occur for any of these modes and may result from a need to compete with an increase in background noise or may reflect increased vigilance or a startle

response. For example, in the presence of potentially masking signals, humpback whales and killer whales have been observed to increase the length of their songs (Miller *et al.*, 2000; Fristrup *et al.*, 2003; Foote *et al.*, 2004), while right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks *et al.*, 2007). In some cases, animals may cease sound production during production of aversive signals (Bowles *et al.*, 1994).

Cerchio *et al.* (2014) used passive acoustic monitoring to document the presence of singing humpback whales off the coast of northern Angola and to opportunistically test for the effect of seismic survey activity on the number of singing whales. Two recording units were deployed between March and December 2008 in the offshore environment; numbers of singers were counted every hour. Generalized Additive Mixed Models were used to assess the effect of survey day (seasonality), hour (diel variation), moon phase, and received levels of noise (measured from a single pulse during each ten minute sampled period) on singer number. The number of singers significantly decreased with increasing received level of noise, suggesting that humpback whale breeding activity was disrupted to some extent by the survey activity.

Castellote *et al.* (2012) reported acoustic and behavioral changes by fin whales in response to shipping and airgun noise. Acoustic features of fin whale song notes recorded in the Mediterranean Sea and northeast Atlantic Ocean were compared for areas with different shipping noise levels and traffic intensities and during a seismic airgun survey. During the first 72 h of the survey, a steady decrease in song received levels and bearings to singers indicated that whales moved away from the acoustic source and out of the study area. This displacement persisted for a time period well beyond the 10-day duration of seismic airgun activity, providing evidence that fin whales may avoid an area for an extended period in the presence of increased noise. The

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authors hypothesize that fin whale acoustic communication is modified to compensate for increased background noise and that a sensitization process may play a role in the observed temporary displacement.

Seismic pulses at average received levels of 131 dB re 1 µPa2-s caused blue whales to increase call production (Di Iorio and Clark, 2010). In contrast, McDonald *et al.* (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the acoustic source vessel (estimated received level 143 dB pk-pk). Blackwell *et al.* (2013) found that bowhead whale call rates dropped significantly at onset of airgun use at sites with a median distance of 41-45 km from the survey. Blackwell *et al.* (2015) expanded this analysis to show that whales actually increased calling rates as soon as airgun signals were detectable before ultimately decreasing calling rates at higher received levels (*i.e.*, 10-minute SELcum of ~127 dB). Overall, these results suggest that bowhead whales may adjust their vocal output in an effort to compensate for noise before ceasing vocalization effort and ultimately deflecting from the acoustic source (Blackwell *et al.*, 2013, 2015). These studies demonstrate that even low levels of noise received far from the source can induce changes in vocalization and/or behavior for mysticetes.

Avoidance is the displacement of an individual from an area or migration path as a result of the presence of a sound or other stressors, and is one of the most obvious manifestations of disturbance in marine mammals (Richardson *et al.*, 1995). For example, gray whales are known to change direction—deflecting from customary migratory paths—in order to avoid noise from seismic surveys (Malme *et al.*, 1984). Humpback whales showed avoidance behavior in the presence of an active seismic array during observational studies and controlled exposure experiments in western Australia (McCauley *et al.*, 2000). Avoidance may be short-term, with

animals returning to the area once the noise has ceased (*e.g.*, Bowles *et al.*, 1994; Goold, 1996; Stone *et al.*, 2000; Morton and Symonds, 2002; Gailey *et al.*, 2007). Longer-term displacement is possible, however, which may lead to changes in abundance or distribution patterns of the affected species in the affected region if habituation to the presence of the sound does not occur (*e.g.*, Bejder *et al.*, 2006; Teilmann *et al.*, 2006).

A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. The flight response differs from other avoidance responses in the intensity of the response (*e.g.*, directed movement, rate of travel). Relatively little information on flight responses of marine mammals to anthropogenic signals exist, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus, 1996). The result of a flight response could range from brief, temporary exertion and displacement from the area where the signal provokes flight to, in extreme cases, marine mammal strandings (Evans and England, 2001). However, it should be noted that response to a perceived predator does not necessarily invoke flight (Ford and Reeves, 2008), and whether individuals are solitary or in groups may influence the response.

Behavioral disturbance can also impact marine mammals in more subtle ways. Increased vigilance may result in costs related to diversion of focus and attention (*i.e.*, when a response consists of increased vigilance, it may come at the cost of decreased attention to other critical behaviors such as foraging or resting). These effects have generally not been demonstrated for marine mammals, but studies involving fish and terrestrial animals have shown that increased vigilance may substantially reduce feeding rates (*e.g.*, Beauchamp and Livoreil, 1997; Fritz *et al.*, 2002; Purser and Radford, 2011). In addition, chronic disturbance can cause population declines through reduction of fitness (*e.g.*, decline in body condition) and subsequent reduction

in reproductive success, survival, or both (*e.g.*, Harrington and Veitch, 1992; Daan *et al.*, 1996; Bradshaw *et al.*, 1998). However, Ridgway *et al.* (2006) reported that increased vigilance in bottlenose dolphins exposed to sound over a five-day period did not cause any sleep deprivation or stress effects.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (24-hour cycle). Disruption of such functions resulting from reactions to stressors such as sound exposure are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall *et al.*, 2007). Consequently, a behavioral response lasting less than one day and not recurring on subsequent days is not considered particularly severe unless it could directly affect reproduction or survival (Southall *et al.*, 2007). Note that there is a difference between multi-day substantive behavioral reactions and multi-day anthropogenic activities. For example, just because an activity lasts for multiple days does not necessarily mean that individual animals are either exposed to activity-related stressors for multiple days or, further, exposed in a manner resulting in sustained multi-day substantive behavioral responses.

Stone (2015) reported data from at-sea observations during 1,196 seismic surveys from 1994 to 2010. When large arrays of airguns (considered to be 500 in3 or more) were firing, lateral displacement, more localized avoidance, or other changes in behavior were evident for most odontocetes. However, significant responses to large arrays were found only for the minke whale and fin whale. Behavioral responses observed included changes in swimming or surfacing behavior, with indications that cetaceans remained near the water surface at these times. Cetaceans were recorded as feeding less often when large arrays were active. Behavioral observations of gray whales during a seismic survey monitored whale movements and respirationspre-, during and post-seismic survey (Gailey *et al.*, 2016). Behavioral state and water

depth were the best `natural' predictors of whale movements and respiration and, after considering natural variation, none of the response variables were significantly associated with seismic survey or vessel sounds.

Stress Responses—An animal's perception of a threat may be sufficient to trigger stress responses consisting of some combination of behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses (*e.g.*, Seyle, 1950; Moberg, 2000). In many cases, an animal's first and sometimes most economical (in terms of energetic costs) response is behavioral avoidance of the potential stressor. Autonomic nervous system responses to stress typically involve changes in heart rate, blood pressure, and gastrointestinal activity. These responses have a relatively short duration and may or may not have a significant long-term effect on an animal's fitness.

Neuroendocrine stress responses often involve the hypothalamus-pituitary-adrenal system. Virtually all neuroendocrine functions that are affected by stress—including immune competence, reproduction, metabolism, and behavior—are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction, altered metabolism, reduced immune competence, and behavioral disturbance (*e.g.*, Moberg, 1987; Blecha, 2000). Increases in the circulation of glucocorticoids are also equated with stress (Romano *et al.*, 2004).

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and "distress" is the cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose serious fitness consequences. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs

of a stress response, energy resources must be diverted from other functions. This state of distress will last until the animal replenishes its energetic reserves sufficiently to restore normal function.

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses are well-studied through controlled experiments and for both laboratory and free-ranging animals (*e.g.*, Holberton *et al.*, 1996; Hood *et al.*, 1998; Jessop *et al.*, 2003; Krausman *et al.*, 2004; Lankford *et al.*, 2005). Stress responses due to exposure to anthropogenic sounds or other stressors and their effects on marine mammals have also been reviewed (Fair and Becker, 2000; Romano *et al.*, 2002b) and, more rarely, studied in wild populations (*e.g.*, Romano *et al.*, 2002a). For example, Rolland *et al.* (2012) found that noise reduction from reduced ship traffic in the Bay of Fundy was associated with decreased stress in North Atlantic right whales. These and other studies lead to a reasonable expectation that some marine mammals will experience physiological stress responses upon exposure to acoustic stressors and that it is possible that some of these would be classified as "distress." In addition, any animal experiencing TTS would likely also experience stress responses (NRC, 2003).

Auditory Masking—Sound can disrupt behavior through masking, or interfering with, an animal's ability to detect, recognize, or discriminate between acoustic signals of interest (*e.g.*, those used for intraspecific communication and social interactions, prey detection, predator avoidance, navigation) (Richardson *et al.*, 1995; Erbe *et al.*, 2016). Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may occur whether the sound is natural (*e.g.*, snapping shrimp, wind, waves, precipitation) or anthropogenic (*e.g.*, shipping, sonar, seismic exploration) in origin. The ability of a noise source to mask biologically important sounds depends on the

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characteristics of both the noise source and the signal of interest (*e.g.*, signal-to-noise ratio, temporal variability, direction), in relation to each other and to an animal's hearing abilities (*e.g.*, sensitivity, frequency range, critical ratios, frequency discrimination, directional discrimination, age or TTS hearing loss), and existing ambient noise and propagation conditions.

Under certain circumstances, marine mammals experiencing significant masking could also be impaired from maximizing their performance fitness in survival and reproduction. Therefore, when the coincident (masking) sound is man-made, it may be considered harassment when disrupting or altering critical behaviors. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without resulting in TS) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

The frequency range of the potentially masking sound is important in determining any potential behavioral impacts. For example, low-frequency signals may have less effect on high-frequency echolocation sounds produced by odontocetes but are more likely to affect detection of mysticete communication calls and other potentially important natural sounds such as those produced by surf and some prey species. The masking of communication signals by anthropogenic noise may be considered as a reduction in the communication space of animals (*e.g.*, Clark *et al.*, 2009) and may result in energetic or other costs as animals change their vocalization behavior (*e.g.*, Miller *et al.*, 2000; Foote *et al.*, 2004; Parks *et al.*, 2007; Di Iorio and Clark, 2009; Holt *et al.*, 2009). Masking can be reduced in situations where the signal and noise come from different directions (Richardson *et al.*, 1995), through amplitude modulation of the signal, or through other compensatory behaviors (Houser and Moore, 2014). Masking can be tested directly in captive species (*e.g.*, Erbe, 2008), but in wild populations it must be either

modeled or inferred from evidence of masking compensation. There are few studies addressing real-world masking sounds likely to be experienced by marine mammals in the wild (*e.g.*, Branstetter *et al.*, 2013).

Masking affects both senders and receivers of acoustic signals and can potentially have long-term chronic effects on marine mammals at the population level as well as at the individual level. Low-frequency ambient sound levels have increased by as much as 20 dB (more than three times in terms of SPL) in the world's ocean from pre-industrial periods, with most of the increase from distant commercial shipping (Hildebrand, 2009). All anthropogenic sound sources, but especially chronic and lower-frequency signals (*e.g.*, from vessel traffic), contribute to elevated ambient sound levels, thus intensifying masking.

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (*e.g.*, Simard *et al.* 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (*e.g.*, Gedamke 2011; Guerra *et al.* 2011, 2016; Klinck *et al.* 2012; Guan *et al.* 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra *et al.* (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background

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levels during intervals between pulses reduced blue and fin whale communication space by as much as 36-51 percent when a seismic survey was operating 450-2,800 km away. Based on preliminary modeling, Wittekind *et al.* (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Nieukirk *et al.* (2012) and Blackwell *et al.* (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (*e.g.*, Nieukirk *et al.* 2012; Thode *et al.* 2012; Bröker *et al.* 2013; Sciacca *et al.* 2016). As noted above, Cerchio *et al.* (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (*e.g.*, Di Iorio and Clark 2010; Castellote *et al.* 2012; Blackwell *et al.* 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (*e.g.*, MacGillivray *et al.* 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses.

Ship Noise

Vessel noise from the *Langseth* could affect marine animals in the proposed survey areas. Houghton *et al.* (2015) proposed that vessel speed is the most important predictor of received noise levels, and Putland *et al.* (2017) also reported reduced sound levels with decreased vessel

speed. Sounds produced by large vessels generally dominate ambient noise at frequencies from

20 to 300 Hz (Richardson *et al.* 1995). However, some energy is also produced at higher

frequencies (Hermannsen *et al.* 2014); low levels of high-frequency sound from vessels has been

shown to elicit responses in harbor porpoise (Dyndo *et al.* 2015). Increased levels of ship noise

have been shown to affect foraging by porpoise (Teilmann *et al.* 2015; Wisniewska *et al.* 2018);

Wisniewska *et al.* (2018) suggest that a decrease in foraging success could have long-term

fitness consequences.

Ship noise, through masking, can reduce the effective communication distance of a

marine mammal if the frequency of the sound source is close to that used by the animal, and if

the sound is present for a significant fraction of time (*e.g.*, Richardson *et al.* 1995; Clark *et al.*

2009; Jensen *et al.* 2009; Gervaise *et al.* 2012; Hatch *et al.* 2012; Rice *et al.* 2014; Dunlop 2015;

Erbe *et al.* 2015; Jones *et al.* 2017; Putland *et al.* 2017). In addition to the frequency and duration

of the masking sound, the strength, temporal pattern, and location of the introduced sound also

play a role in the extent of the masking (Branstetter *et al.* 2013, 2016; Finneran and Branstetter

2013; Sills *et al.* 2017). Branstetter *et al.* (2013) reported that time-domain metrics are also

important in describing and predicting masking. In order to compensate for increased ambient

noise, some cetaceans are known to increase the source levels of their calls in the presence of

elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal

behavior (*e.g.*, Parks *et al.* 2011, 2012, 2016a,b; Castellote *et al.* 2012; Melcón *et al.* 2012;

Azzara *et al.* 2013; Tyack and Janik 2013; Luís *et al.* 2014; Sairanen 2014; Papale *et al.* 2015;

Bittencourt *et al.* 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley *et al.*

2016; Heiler *et al.* 2016; Martins *et al.* 2016; O'Brien *et al.* 2016; Tenessen and Parks 2016).

Harp seals did not increase their call frequencies in environments with increased low-frequency

sounds (Terhune and Bosker 2016). Holt *et al.* (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (*e.g.*, Campana *et al.* 2015; Culloch *et al.* 2016).

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (*e.g.*, MacGillivray *et al.* 2014), possibly causing localized avoidance of the proposed survey area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker *et al.* (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair *et al.* 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana *et al.* 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald *et al.* 2013). Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson *et al.* 1995). Dolphins of many species tolerate and sometimes approach vessels (*e.g.*, Anderwald *et al.* 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams *et al.* 1992). Pirotta *et al.* (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging

activity of bottlenose dolphins. Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana *et al.* 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (*e.g.*, Würsig *et al.* 1998) or dive for an extended period when approached by a vessel (*e.g.*, Kasuya 1986). Based on a single observation, Aguilar Soto *et al.* (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

In summary, project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound (NSF-USGS 2011).

Ship Strike

Vessel collisions with marine mammals, or ship strikes, can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus, 2001). An animal at the surface may be struck directly by a vessel, a surfacing animal may hit the bottom of a vessel, or an animal just below the surface may be cut by a vessel's propeller. Superficial strikes may not kill or result in the death of the animal. These interactions are typically associated with large whales (*e.g.*, fin whales), which are occasionally found draped across the bulbous bow of large commercial ships upon arrival in port. Although smaller cetaceans are more maneuverable in relation to large vessels than are large whales, they may also be susceptible to strike. The

severity of injuries typically depends on the size and speed of the vessel, with the probability of death or serious injury increasing as vessel speed increases (Knowlton and Kraus, 2001; Laist *et al.*, 2001; Vanderlaan and Taggart, 2007; Conn and Silber, 2013). Impact forces increase with speed, as does the probability of a strike at a given distance (Silber *et al.*, 2010; Gende *et al.*, 2011).

Pace and Silber (2005) also found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75 percent as vessel speed increased from 10 to 14 kn, and exceeded 90 percent at 17 kn. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death through increased likelihood of collision by pulling whales toward the vessel (Clyne, 1999; Knowlton *et al.*, 1995). In a separate study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 kn. The chances of a lethal injury decline from approximately 80 percent at 15 kn to approximately 20 percent at 8.6 kn. At speeds below 11.8 kn, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward one hundred percent above 15 kn.

The *Langseth* travels at a speed of 4.1 kn (7.6 km/h) while towing seismic survey gear (LGL 2018). At this speed, both the possibility of striking a marine mammal and the possibility of a strike resulting in serious injury or mortality are discountable. At average transit speed, the probability of serious injury or mortality resulting from a strike is less than 50 percent. However, the likelihood of a strike actually happening is again discountable. Ship strikes, as analyzed in the studies cited above, generally involve commercial shipping, which is much more common in

both space and time than is geophysical survey activity. Jensen and Silber (2004) summarized ship strikes of large whales worldwide from 1975-2003 and found that most collisions occurred in the open ocean and involved large vessels (*e.g.*, commercial shipping). No such incidents were reported for geophysical survey vessels during that time period.

It is possible for ship strikes to occur while traveling at slow speeds. For example, a hydrographic survey vessel traveling at low speed (5.5 kn) while conducting mapping surveys off the central California coast struck and killed a blue whale in 2009. The State of California determined that the whale had suddenly and unexpectedly surfaced beneath the hull, with the result that the propeller severed the whale's vertebrae, and that this was an unavoidable event. This strike represents the only such incident in approximately 540,000 hours of similar coastal mapping activity ($p = 1.9 \times 10^{-6}$; 95% CI = 0-5.5×10^{-6}; NMFS, 2013b). In addition, a research vessel reported a fatal strike in 2011 of a dolphin in the Atlantic, demonstrating that it is possible for strikes involving smaller cetaceans to occur. In that case, the incident report indicated that an animal apparently was struck by the vessel's propeller as it was intentionally swimming near the vessel. While indicative of the type of unusual events that cannot be ruled out, neither of these instances represents a circumstance that would be considered reasonably foreseeable or that would be considered preventable.

Although the likelihood of the vessel striking a marine mammal is low, we require a robust ship strike avoidance protocol (see "Proposed Mitigation"), which we believe eliminates any foreseeable risk of ship strike. We anticipate that vessel collisions involving a seismic data acquisition vessel towing gear, while not impossible, represent unlikely, unpredictable events for which there are no preventive measures. Given the required mitigation measures, the relatively slow speed of the vessel towing gear, the presence of bridge crew watching for obstacles at all

times (including marine mammals), and the presence of marine mammal observers, we believe that the possibility of ship strike is discountable and, further, that were a strike of a large whale to occur, it would be unlikely to result in serious injury or mortality. No incidental take resulting from ship strike is anticipated, and this potential effect of the specified activity will not be discussed further in the following analysis.

Stranding – When a living or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is a "stranding" (Geraci *et al.*, 1999; Perrin and Geraci, 2002; Geraci and Lounsbury, 2005; NMFS, 2007). The legal definition for a stranding under the MMPA is that "(A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance."

Marine mammals strand for a variety of reasons, such as infectious agents, biotoxicosis, starvation, fishery interaction, ship strike, unusual oceanographic or weather events, sound exposure, or combinations of these stressors sustained concurrently or in series. However, the cause or causes of most strandings are unknown (Geraci *et al.*, 1976; Eaton, 1979; Odell *et al.*, 1980; Best, 1982). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors

commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos, 2000; Creel, 2005; DeVries *et al.*, 2003; Fair and Becker, 2000; Foley *et al.*, 2001; Moberg, 2000; Relyea, 2005a; 2005b, Romero, 2004; Sih *et al.*, 2004).

Use of military tactical sonar has been implicated in a majority of investigated stranding events. Most known stranding events have involved beaked whales, though a small number have involved deep-diving delphinids or sperm whales (*e.g.*, Mazzariol *et al.*, 2010; Southall *et al.*, 2013). In general, long duration (~1 second) and high-intensity sounds (>235 dB SPL) have been implicated in stranding events (Hildebrand, 2004). With regard to beaked whales, mid-frequency sound is typically implicated (when causation can be determined) (Hildebrand, 2004). Although seismic airguns create predominantly low-frequency energy, the signal does include a mid-frequency component. We have considered the potential for the proposed surveys to result in marine mammal stranding and have concluded that, based on the best available information, stranding is not expected to occur.

Effects to Prey – Marine mammal prey varies by species, season, and location and, for some, is not well documented. Fish react to sounds which are especially strong and/or intermittent low-frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of pulsed sound on fish, although several are based on studies in support of construction projects (*e.g.*, Scholik and Yan, 2001, 2002; Popper and Hastings, 2009). Sound pulses at received levels of 160 dB may cause subtle changes in fish behavior. SPLs of 180 dB may cause noticeable changes in behavior (Pearson *et al.*, 1992; Skalski *et al.*, 1992).

SPLs of sufficient strength have been known to cause injury to fish and fish mortality. The most likely impact to fish from survey activities at the project area would be temporary avoidance of the area. The duration of fish avoidance of a given area after survey effort stops is unknown, but a rapid return to normal recruitment, distribution and behavior is anticipated.

Information on seismic airgun impacts to zooplankton, which represent an important prey type for mysticetes, is limited. However, McCauley *et al.* (2017) reported that experimental exposure to a pulse from a 150 in^3 airgun decreased zooplankton abundance when compared with controls, as measured by sonar and net tows, and caused a two- to threefold increase in dead adult and larval zooplankton. Although no adult krill were present, the study found that all larval krill were killed after air gun passage. Impacts were observed out to the maximum 1.2 km range sampled.

In general, impacts to marine mammal prey are expected to be limited due to the relatively small temporal and spatial overlap between the proposed survey and any areas used by marine mammal prey species. The proposed use of airguns as part of an active seismic array survey would occur over a relatively short time period (~19 days) at two locations and would occur over a very small area relative to the area available as marine mammal habitat in the northeast Pacific Ocean near the Axial Seamount. We believe any impacts to marine mammals due to adverse effects to their prey would be insignificant due to the limited spatial and temporal impact of the proposed survey. However, adverse impacts may occur to a few species of fish and to zooplankton.

Acoustic Habitat – Acoustic habitat is the soundscape—which encompasses all of the sound present in a particular location and time, as a whole—when considered from the perspective of the animals experiencing it. Animals produce sound for, or listen for sounds

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produced by, conspecifics (communication during feeding, mating, and other social activities), other animals (finding prey or avoiding predators), and the physical environment (finding suitable habitats, navigating). Together, sounds made by animals and the geophysical environment (*e.g.*, produced by earthquakes, lightning, wind, rain, waves) make up the natural contributions to the total acoustics of a place. These acoustic conditions, termed acoustic habitat, are one attribute of an animal's total habitat.

Soundscapes are also defined by, and acoustic habitat influenced by, the total contribution of anthropogenic sound. This may include incidental emissions from sources such as vessel traffic, or may be intentionally introduced to the marine environment for data acquisition purposes (as in the use of airgun arrays). Anthropogenic noise varies widely in its frequency content, duration, and loudness and these characteristics greatly influence the potential habitat-mediated effects to marine mammals (please see also the previous discussion on masking under "Acoustic Effects"), which may range from local effects for brief periods of time to chronic effects over large areas and for long durations. Depending on the extent of effects to habitat, animals may alter their communications signals (thereby potentially expending additional energy) or miss acoustic cues (either conspecific or adventitious). For more detail on these concepts see, *e.g.*, Barber *et al.*, 2010; Pijanowski *et al.*, 2011; Francis and Barber, 2013; Lillis *et al.*, 2014.

Problems arising from a failure to detect cues are more likely to occur when noise stimuli are chronic and overlap with biologically relevant cues used for communication, orientation, and predator/prey detection (Francis and Barber, 2013). Although the signals emitted by seismic airgun arrays are generally low frequency, they would also likely be of short duration and transient in any given area due to the nature of these surveys. As described previously,

exploratory surveys such as these cover a large area but would be transient rather than focused in a given location over time and therefore would not be considered chronic in any given location.

In summary, activities associated with the proposed action are not likely to have a permanent, adverse effect on any fish habitat or populations of fish species or on the quality of acoustic habitat. Thus, any impacts to marine mammal habitat are not expected to cause significant or long-term consequences for individual marine mammals or their populations.

Estimated Take

This section provides an estimate of the number of incidental takes proposed for authorization through this IHA, which will inform both NMFS' consideration of "small numbers" and the negligible impact determination.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of 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).

Authorized takes would primarily be by Level B harassment, as use of seismic airguns has the potential to result in disruption of behavioral patterns for individual marine mammals. There is also some potential for auditory injury (Level A harassment) for mysticetes and high frequency cetaceans (*i.e.*, kogiidae spp.), due to larger predicted auditory injury zones for those functional hearing groups. The proposed mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable.

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Auditory injury is unlikely to occur for mid-frequency cetaceans, otariid pinnipeds, and phocid pinnipeds given very small modeled zones of injury for those species (up to 43.7 m). Moreover, the source level of the array is a theoretical definition assuming a point source and measurement in the far-field of the source (MacGillivray, 2006). As described by Caldwell and Dragoset (2000), an array is not a point source, but one that spans a small area. In the far-field, individual elements in arrays will effectively work as one source because individual pressure peaks will have coalesced into one relatively broad pulse. The array can then be considered a "point source." For distances within the near-field, *i.e.*, approximately 2-3 times the array dimensions, pressure peaks from individual elements do not arrive simultaneously because the observation point is not equidistant from each element. The effect is destructive interference of the outputs of each element, so that peak pressures in the near-field will be significantly lower than the output of the largest individual element. Here, the 230 dB peak isopleth distances would in all cases be expected to be within the near-field of the array where the definition of source level breaks down. Therefore, actual locations within this distance of the array center where the sound level exceeds 230 dB peak SPL would not necessarily exist. In general, Caldwell and Dragoset (2000) suggest that the near-field for airgun arrays is considered to extend out to approximately 250 m.

In order to provide quantitative support for this theoretical argument, we calculated expected maximum distances at which the near-field would transition to the far-field (Table 5). For a specific array one can estimate the distance at which the near-field transitions to the far-field by:

$$D = \frac{L^2}{4\lambda}$$

with the condition that $D \gg \lambda$, and where D is the distance, L is the longest dimension of the

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array, and λ is the wavelength of the signal (Lurton, 2002). Given that λ can be defined by:

$$\lambda = \frac{v}{f}$$

where f is the frequency of the sound signal and v is the speed of the sound in the medium of interest, one can rewrite the equation for D as:

$$D = \frac{fL^2}{4v}$$

and calculate D directly given a particular frequency and known speed of sound (here assumed to be 1,500 meters per second in water, although this varies with environmental conditions).

To determine the closest distance to the arrays at which the source level predictions in Table 1 are valid (i.e., maximum extent of the near-field), we calculated D based on an assumed frequency of 1 kHz. A frequency of 1 kHz is commonly used in near-field/far-field calculations for airgun arrays (Zykov and Carr, 2014; MacGillivray, 2006; NSF and USGS, 2011), and based on representative airgun spectrum data and field measurements of an airgun array used on the R/V Marcus G. Langseth, nearly all (greater than 95 percent) of the energy from airgun arrays is below 1 kHz (Tolstoy et al., 2009). Thus, using 1 kHz as the upper cut-off for calculating the maximum extent of the near-field should reasonably represent the near-field extent in field conditions.

If the largest distance to the peak sound pressure level threshold was equal to or less than the longest dimension of the array (i.e., under the array), or within the near-field, then received levels that meet or exceed the threshold in most cases are not expected to occur. This is because within the near-field and within the dimensions of the array, the source levels specified in Table 1 are overestimated and not applicable. In fact, until one reaches a distance of approximately three or four times the near-field distance the average intensity of sound at any given distance

from the array is still less than that based on calculations that assume a directional point source (Lurton, 2002). The 6,600 in^3 airgun array used in the 2D survey has an approximate diagonal of 28.8 m, resulting in a near-field distance of 138.7 m at 1 kHz (NSF and USGS, 2011). Field measurements of this array indicate that the source behaves like multiple discrete sources, rather than a directional point source, beginning at approximately 400 m (deep site) to 1 km (shallow site) from the center of the array (Tolstoy *et al.*, 2009), distances that are actually greater than four times the calculated 140-m near-field distance. Within these distances, the recorded received levels were always lower than would be predicted based on calculations that assume a directional point source, and increasingly so as one moves closer towards the array (Tolstoy *et al.*, 2009). Similarly, the 3,300 in^3 airgun array used in the 3D survey has an approximate diagonal of 17.9 m, resulting in a near-field distance of 53.5 m at 1 kHz (NSF and USGS, 2011). Given this, relying on the calculated distances (138.7 m for the 2D survey and 53.5 m for the 3D survey) as the distances at which we expect to be in the near-field is a conservative approach since even beyond this distance the acoustic modeling still overestimates the actual received level. Within the near-field, in order to explicitly evaluate the likelihood of exceeding any particular acoustic threshold, one would need to consider the exact position of the animal, its relationship to individual array elements, and how the individual acoustic sources propagate and their acoustic fields interact. Given that within the near-field and dimensions of the array source levels would be below those in Table 5, we believe exceedance of the peak pressure threshold would only be possible under highly unlikely circumstances.

Therefore, we expect the potential for Level A harassment of mid-frequency cetaceans, otariid pinnipeds, and phocid pinnipeds to be de minimis, even before the likely moderating effects of aversion and/or other compensatory behaviors (*e.g.*, Nachtigall *et al.*, 2018) are

considered. We do not believe that Level A harassment is a likely outcome for any mid-frequency cetacean, otariid pinniped, or phocid pinniped and do not propose to authorize any Level A harassment for these species.

As described previously, no mortality is anticipated or proposed to be authorized for this activity. Below we describe how the take is estimated.

Generally speaking, we estimate take by considering: (1) acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; (2) the area or volume of water that will be ensonified above these levels in a day; (3) the density or occurrence of marine mammals within these ensonified areas; and, (4) and the number of days of activities. We note that while these basic factors can contribute to a basic calculation to provide an initial prediction of takes, additional information that can qualitatively inform take estimates is also sometimes available (*e.g.*, previous monitoring results or average group size). Below, we describe the factors considered here in more detail and present the proposed take estimate.

Acoustic Thresholds

Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound above which exposed marine mammals would be reasonably expected to be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment for non-explosive sources – Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.*, frequency, predictability, duty cycle), the environment (*e.g.*, bathymetry), and the receiving animals (hearing, motivation, experience,

demography, behavioral context) and can be difficult to predict (Southall *et al.,* 2007, Ellison *et al.*, 2012). Based on what the available science indicates and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner we consider Level B harassment when exposed to underwater anthropogenic noise above received levels of 120 dB re 1 µPa (rms) for continuous (*e.g.,* vibratory pile-driving, drilling) and above 160 dB re 1 µPa (rms) for non-explosive impulsive (*e.g.*, seismic airguns) or intermittent (*e.g.*, scientific sonar) sources. L-DEO's proposed activity includes the use of impulsive seismic sources. Therefore, the 160 dB re 1 µPa (rms) criteria is applicable for analysis of Level B harassment.

Level A harassment for non-explosive sources - NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) (Technical Guidance, 2018) identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive. L-DEO's proposed seismic survey includes the use of impulsive (seismic airguns) sources.

These thresholds are provided in the table below. The references, analysis, and methodology used in the development of the thresholds are described in NMFS 2018 Technical Guidance, which may be accessed at *https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance*.

Table 3. Thresholds identifying the onset of Permanent Threshold Shift.

	PTS Onset Acoustic Thresholds[*]

Hearing Group	(Received Level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	Cell 1 $L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	Cell 2 $L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	Cell 3 $L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	Cell 4 $L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	Cell 5 $L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	Cell 6 $L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	Cell 7 $L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	Cell 8 $L_{E,PW,24h}$: 201 dB
Otariid Pinnipeds (OW) (Underwater)	Cell 9 $L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	Cell 10 $L_{E,OW,24h}$: 219 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (L_{pk}) has a reference value of 1 μPa, and cumulative sound exposure level (L_E) has a reference value of 1μPa²s. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (*i.e.*, varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Ensonified Area

Here, we describe operational and environmental parameters of the activity that will feed into identifying the area ensonified above the acoustic thresholds, which include source levels and transmission loss coefficient.

The proposed 3D survey would acquire data with the 18-airgun array with a total discharge of 3,300 in³ towed at a depth of 10 m. The proposed 2D survey would acquire data using the 36-airgun array with a total discharge of 6,600 in³ at a maximum tow depth of 12 m. L-

DEO model results are used to determine the 160-dBrms radius for the 18-airgun array, 36-airgun array, and 40-in^3 airgun in deep water (>1000 m) down to a maximum water depth of 2,000 m. Received sound levels were predicted by L-DEO's model (Diebold *et al.*, 2010) which uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (approximately 1600 m), intermediate water depth on the slope (approximately 600–1100 m), and shallow water (approximately 50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy *et al.* 2009; Diebold *et al.* 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive Level A and Level B isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2,000 m. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant.

In deep and intermediate-water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of NSF-USGS, 2011).. Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO

model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths.

For deep water (>1,000 m), L-DEO used the deep-water radii obtained from model results down to a maximum water depth of 2000 m. The radii for intermediate water depths (100–1,000 m) were derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (See Fig. 16 in Appendix H of NSF-USGS, 2011).

Measurements have not been reported for the single 40-in^3 airgun. L-DEO model results are used to determine the 160-dB (rms) radius for the 40-in^3 airgun at a 12 m tow depth in deep water (See LGL 2018, Figure A-2). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results.

L-DEO's modeling methodology is described in greater detail in the IHA application (LGL 2018). The estimated distances to the Level B harassment isopleth for the *Langseth's* 18-airgun array, 36-airgun array, and single 40-in^3 airgun are shown in Table 4.

Table 4. Predicted Radial Distances from R/V *Langseth* Seismic Sources to Isopleths Corresponding to Level B Harassment Threshold.

Source and volume	Tow depth (m)	Distance (m)[a]
Single Bolt airgun (40 in^3)	12	431

2 strings, 18 airguns (3,300 in^3)	10	3,758
4 strings, 36 airguns (6,600 in^3)	12	6,733

[a] Distance based on L-DEO model results

Predicted distances to Level A harassment isopleths, which vary based on marine

mammal hearing groups, were calculated based on modeling performed by L-DEO using the

NUCLEUS software program and the NMFS User Spreadsheet, described below. The updated

acoustic thresholds for impulsive sounds (*e.g.*, airguns) contained in the Technical Guidance

were presented as dual metric acoustic thresholds using both SEL$_{cum}$ and peak sound pressure

metrics (NMFS 2016). As dual metrics, NMFS considers onset of PTS (Level A harassment) to

have occurred when either one of the two metrics is exceeded (*i.e.*, metric resulting in the largest

isopleth). The SEL$_{cum}$ metric considers both level and duration of exposure, as well as auditory

weighting functions by marine mammal hearing group. In recognition of the fact that the

requirement to calculate Level A harassment ensonified areas could be more technically

challenging to predict due to the duration component and the use of weighting functions in the

new SEL$_{cum}$ thresholds, NMFS developed an optional User Spreadsheet that includes tools to

help predict a simple isopleth that can be used in conjunction with marine mammal density or

occurrence to facilitate the estimation of take numbers.

The values for SEL$_{cum}$ and peak SPL for the *Langseth* airgun array were derived from

calculating the modified far-field signature (Table 5). The farfield signature is often used as a

theoretical representation of the source level. To compute the farfield signature, the source level

is estimated at a large distance below the array (*e.g.*, 9 km), and this level is back projected

mathematically to a notional distance of 1 m from the array's geometrical center. However, when

the source is an array of multiple airguns separated in space, the source level from the theoretical

farfield signature is not necessarily the best measurement of the source level that is physically achieved at the source (Tolstoy *et al.* 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively, as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy *et al.* 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. L-DEO used the acoustic modeling methodology as used for Level B harassment with a small grid step of 1 m in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source, including interactions between subarrays which are modeled using the NUCLEUS software to estimate the notional signature and MATLAB software to calculate the pressure signal at each mesh point of a grid.

For a more complete explanation of this modeling approach, please see "Appendix A: Determination of Mitigation Zones" in the IHA application.

Table 5. Modeled Source Levels Based on Modified Farfield Signature for the R/V Langseth 3,300 in^3 Airgun Array, 6,600 in^3 Airgun Array, and single 40 in^3 Airgun.

	Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)	Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)
3,300 in^3 airgun	245.29	250.97	243.61	246.00	251.92

array (Peak SPL$_{flat}$)					
3.300 in^3 airgun array (SEL$_{cum}$)	226.38	226.33	226.66	226.33	227.07
6,600 in^3 airgun array (Peak SPL$_{flat}$)	252.06	252.65	253.24	252.25	252.52
6,600 in^3 airgun array (SEL$_{cum}$)	232.98	232.83	233.08	232.83	232.07
40 in^3 airgun (Peak SPL$_{flat}$)	223.93	N.A.	223.92	223.95	N.A.
40 in^3 airgun (SEL$_{cum}$)	202.99	202.89	204.37	202.89	202.35

In order to more realistically incorporate the Technical Guidance's weighting functions over the seismic array's full acoustic band, unweighted spectrum data for the Langseth's airgun array (modeled in 1 hertz (Hz) bands) was used to make adjustments (dB) to the unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted/weighted spectrum levels were then converted to pressures (μPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted source levels by hearing group that could be directly incorporated within the User Spreadsheet (*i.e.*, to override the Spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's "safe distance" methodology for mobile sources (described by Sivle *et al.*, 2014) with the hearing group-specific weighted source levels, and inputs assuming spherical spreading propagation and source velocities and shot intervals specific to each of the three planned surveys provided in the IHA application, potential radial distances to auditory injury zones were then calculated for SEL$_{cum}$ thresholds.

Inputs to the User Spreadsheets in the form of estimated SLs are shown in Table 5. User Spreadsheets used by L-DEO to estimate distances to Level A harassment isopleths for the 18-airgun array, 36-airgun array, and single 40 in^3 airgun for the surveys are shown in Tables A-3, A-6, and A-10 in Appendix A of the IHA application. Outputs from the User Spreadsheets in the

form of estimated distances to Level A harassment isopleths for the surveys are shown in Table 6. As described above, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the dual metrics (SEL_{cum} and Peak SPL_{flat}) is exceeded (*i.e.*, metric resulting in the largest isopleth).

Table 6. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Source and volume		LF cetaceans	MF cetaceans	HF cetaceans	Phocid pinnipeds	Otariid pinnipeds
Single Bolt airgun (40 in^3)[a]	PTS SEL_{cum}	0.5	0	0	0	0
	PTS Peak	1.76	0.51	12.5	1.98	0.4
2 strings, 18 airguns (3300 in^3)	PTS SEL_{cum}	75.6	0	0.3	2.9	0
	PTS Peak	23.2	11.2	118.7	25.1	9.9
4 strings, 36 airguns (6600 in^3)	PTS SEL_{cum}	426.9	0	1.3	13.9	0
	PTS Peak	38.9	13.6	268.3	43.7	10.6

Note that because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of Level A harassment. However, these tools offer the best way to predict appropriate isopleths when more sophisticated modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the proposed seismic survey, the User Spreadsheet predicts the closest distance at which a stationary animal would not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

Marine Mammal Occurrence

In this section we provide the information about the presence, density, or group dynamics of marine mammals that will inform the take calculations.

In developing their IHA application, L-DEO utilized estimates of cetacean densities in the survey area synthesized by Barlow (2016). Observations from NMFS Southwest Fisheries Science Center (SWFSC) ship surveys off of Oregon and Washington (up to 556 km from shore) between 1991 and 2014 were pooled. Systematic, offshore, at-sea survey data for pinnipeds are more limited. To calculate pinniped densities in the survey area, L-DEO utilized methods described in U.S. Navy (2010) which calculated density estimates for pinnipeds off Washington at different times of the year using information on breeding and migration, population estimates from shore counts, and areas used by different species while at sea. The densities calculated by the Navy were updated by L-DEO using stock abundances presented in the latest SARs (*e.g.*, Caretta *et al.*, 2018).

While the IHA application was in review by NMFS, the U.S. Navy published the Marine Species Density Database Phase III for the Northwest Training and Testing (NWTT) Study Area (Navy 2018). The proposed geophysical survey area is located near the western boundary of the defined NWTT Offshore Study Area.

For several cetacean species, the Navy updated densities estimated by line-transect surveys or mark-recapture studies (*e.g.*, Barlow 2016). These methods usually produce a single value for density that is an averaged estimate across very large geographical areas, such as waters within the U.S. EEZ off California, Oregon, and Washington (referred to as a "uniform" density estimate). This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports. The disadvantage of these methods is that they do not provide information on varied concentrations of species in sub-regions of very large areas, and do not estimate density for other seasons or timeframes that were not surveyed. More recently, a newer method called spatial habitat modeling has been used to estimate cetacean densities that address

some of these shortcomings (*e.g.*, Barlow *et al.*, 2009; Becker *et al.*, 2010; 2012a; 2014; Becker *et al.*, 2016; Ferguson *et al.*, 2006; Forney *et al.*, 2012; 2015; Redfern *et al.*, 2006). (Note that spatial habitat models are also referred to as "species distribution models" or "habitat-based density models.") These models estimate density as a continuous function of habitat variables (*e.g.*, sea surface temperature, seafloor depth) and thus, within the study area that was modeled, densities can be predicted at all locations where these habitat variables can be measured or estimated. Spatial habitat models therefore allow estimates of cetacean densities on finer scales than traditional line-transect or mark-recapture analyses.

The methods used to estimate pinniped at-sea densities are typically different than those used for cetaceans, because pinnipeds are not limited to the water and spend a significant amount of time on land (*e.g.*, at rookeries). Pinniped abundance is generally estimated via shore counts of animals on land at known haulout sites or by counting number of pups weaned at rookeries and applying a correction factor to estimate the abundance of the population (for example Harvey *et al.*, 1990; Jeffries *et al.*, 2003; Lowry, 2002; Sepulveda *et al.*, 2009). Estimating in-water densities from land-based counts is difficult given the variability in foraging ranges, migration, and haulout behavior between species and within each species, and is driven by factors such as age class, sex class, breeding cycles, and seasonal variation. Data such as age class, sex class, and seasonal variation are often used in conjunction with abundance estimates from known haulout sites to assign an in-water abundance estimate for a given area. The total abundance divided by the area of the region provides a representative in-water density estimate for each species in a different location, which enables analyses of in-water stressors resulting from at-sea Navy testing or training activities. In addition to using shore counts to estimate

pinniped density, traditional line-transect derived estimates are also used, particularly in open ocean areas.

Because the Navy's density calculations for many species included spatial habitat modeling and demographic information, we utilized the Navy Marine Species Density Database (NMSDD) to estimate densities and resulting take of marine mammals from the proposed geophysical survey. Where available, the appropriate seasonal density estimate from the NMSDD was used in the estimation here (*i.e.*, summer). For species with a quantitative density range within or around the proposed survey area, the maximum presented density was conservatively used. Background information on the density calculations for each species/guild as well as reported sightings in nearby waters are reported here. Density estimates for each species/guild are found in Table 7.

Humpback Whale

NMFS SWFSC developed a CCE habitat-based density model for humpback whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Six humpback whale sightings (8 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey; all were well inshore of the proposed survey area (RPS 2012b). There were 98 humpback whale sightings (213 animals) made during the July 2012 L-DEO seismic survey off southern Washington, northeast of the proposed survey area (RPS 2012a), and 11 sightings (23 animals) during the July 2012 L-DEO seismic survey off

Oregon, southeast of the proposed survey area (RPS 2012c). No sightings were made near the proposed survey area in the 2014 NMFS Southwest Fisheries Science Center (SWFSC) California Current Ecosystem (CCE) vessel survey (Barlow 2016).

Minke Whale

Density values for minke whales are available for the SWFSC Oregon/Washington and Northern California offshore strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates.

Sightings have been made off Oregon and Washington in shelf and deeper waters (Green *et al.* 1992; Adams *et al.* 2014; Carretta *et al.* 2017). An estimated abundance of 211 minke whales was reported for the Oregon/Washington region based on sightings data from 1991–2005 (Barlow and Forney 2007), whereas a 2008 survey did not record any minke whales while on survey effort (Barlow 2010). The abundance for Oregon/Washington for 2014 was estimated at 507 minke whales (Barlow 2016). There were no sightings of minke whales off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey or during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012b,c). One minke whale was seen during the July 2012 L-DEO seismic survey off southern Washington, north of the proposed survey area (RPS 2012a). No sightings of minke whales were made near the proposed survey area during the 2014 SWFSC CCE vessel survey (Barlow 2016).

Sei Whale

Density values for sei whales are available for the SWFSC Oregon/Washington and Northern California offshore strata for summer/fall (Barlow, 2016). Density data are not

available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates.

Sei whales are rare in the waters off California, Oregon, and Washington (Brueggeman *et al.* 1990; Green *et al.* 1992; Barlow 1994, 1997). Only 16 confirmed sightings were reported for California, Oregon, and Washington during extensive surveys from 1991–2014 (Green *et al.* 1992, 1993; Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow 2003; Forney 2007; Barlow 2010; Carretta *et al.* 2017). Based on surveys conducted in 1991–2008, the estimated abundance of sei whales off the coasts of Oregon and Washington was 52 (Barlow 2010); for 2014, the abundance estimate was 468 (Barlow 2016). Two sightings of four individuals were made during the June–July 2012 L-DEO Juan de Fuca plate seismic survey off Washington/Oregon (RPS 2012b); these were well inshore of the proposed survey area (~125° W). No sei whales were sighted during the July 2012 L-DEO seismic surveys north and south of the proposed survey area (RPS 2012a,c).

Fin Whale

NMFS SWFSC developed a CCE habitat-based density model for fin whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Fin whales are routinely sighted during surveys off Oregon and Washington (Barlow and Forney 2007; Barlow 2010; Adams *et al.* 2014; Calambokidis *et al.* 2015; Edwards *et al.* 2015; Carretta *et al.* 2017), including in coastal as well as offshore waters. They have also been

detected acoustically near the proposed study area during June–August (Edwards *et al.* 2015). There is one sighting of a fin whale in the Ocean Biogeographic Information System (OBIS) database within the proposed survey area, which was made in August 2005 during the SWFSC Collaborative Survey of Cetacean Abundance and the Pelagic Ecosystem (CSCAPE) Marine Mammal Survey, and several other sightings in adjacent waters (OBIS 2018). Eight fin whale sightings (19 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey, including two sightings (4 animals) in the vicinity of the proposed survey area; sightings were made in waters 2369–3940 m deep (RPS 2012b). Fourteen fin whale sightings (28 animals) were made during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). No fin whales were sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c). Fin whales were also seen off southern Oregon during July 2012 in water >2000 m deep during surveys by Adams *et al.* (2014).

Blue Whale

NMFS SWFSC developed a CCE habitat-based density model for blue whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

The nearest sighting of blue whales is ~55 km to the southwest (OBIS 2018), and there are several other sightings in adjacent waters (Carretta *et al.* 2018; OBIS 2018). Satellite

telemetry suggests that blue whales are present in waters offshore of Oregon and Washington during fall and winter (Bailey *et al.* 2009; Hazen *et al.* 2017).

Sperm Whale

NMFS SWFSC developed a CCE habitat-based density model for sperm whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

There is one sighting of a sperm whale in the vicinity of the survey area in the OBIS database that was made in July 1996 during the SWFSC ORCAWALE Marine Mammal Survey (OBIS 2018), and several other sightings in adjacent waters (Carretta *et al.* 2018; OBIS 2018). Sperm whale sightings were also made in the vicinity of the proposed survey area during the 2014 SWFSC vessel survey (Barlow 2016). A single sperm whale was sighted during the 2009 ETOMO survey, north of the proposed survey area (Holst 2017). Sperm whales were detected acoustically in waters near the proposed survey area in August 2016 during the SWFSC Passive Acoustics Survey of Cetacean Abundance Levels (PASCAL) study using drifting acoustic recorders (Keating *et al.* 2018).

Pygmy and Dwarf Sperm Whales (*Kogia* guild)

Kogia species are treated as a guild off the U.S. West Coast (Barlow & Forney, 2007). Barlow (2016) provided stratified density estimates for *Kogia* spp. for waters off California, Oregon, and Washington; these were used for all seasons for both the Northern California and

Oregon/Washington strata. In the absence of other data, the Barlow (2016) Oregon/Washington estimate was also used for the area northwest of the SWFSC strata for all seasons.

Pygmy and dwarf sperm whales are rarely sighted off Oregon and Washington, with only one sighting of an unidentified *Kogia* sp. beyond the U.S. EEZ, during the 1991–2014 NOAA vessel surveys (Carretta *et al.* 2017). This sighting was made in October 1993 during the SWFSC PODS Marine Mammal Survey ~150 km to the south of the proposed survey area (OBIS 2018). Norman *et al.* (2004) reported eight confirmed stranding records of pygmy sperm whales for Oregon and Washington, five of which occurred during autumn and winter.

Baird's Beaked Whale

NMFS SWFSC developed a CCE habitat-based density model for Baird's beaked whale which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Green *et al.* (1992) sighted five groups during 75,050 km of aerial survey effort in 1989–1990 off Washington/Oregon spanning coastal to offshore waters: two in slope waters and three in offshore waters. Two groups were sighted during summer/fall 2008 surveys off Washington/Oregon, in waters >2000 m deep (Barlow 2010). Acoustic monitoring offshore Washington detected Baird's beaked whale pulses during January through November 2011, with peaks in February and July (Širović *et al.* 2012b *in* USN 2015). Baird's beaked whales were detected acoustically near the proposed survey area in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating *et al.* 2018). There is one sighting of a Baird's

beaked whale near the survey area in the OBIS database that was made in August 2005 during the SWFSC CSCAPE Marine Mammal Survey (OBIS 2018).

Small Beaked Whale Guild

NMFS has developed habitat-based density models for a small beaked whale guild in the CCE (Becker *et al.*, 2012b; Forney *et al.*, 2012). The small beaked whale guild includes Cuvier's beaked whale and beaked whales of the genus *Mesoplodon,* including Blainville's beaked whale, Hubbs' beaked whale, and Stejneger's beaked whale. NMFS SWFSC developed a CCE habitat-based density model for the small beaked whale guild which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Four beaked whale sightings were reported in water depths >2000 m off Oregon/Washington during surveys in 2008 (Barlow 2010). None were seen in 1996 or 2001 (Barlow 2003), and several were recorded from 1991 to 1995 (Barlow 1997). One Cuvier's beaked whale sighting was made east of the proposed survey area during 2014 (Barlow 2016). Acoustic monitoring in Washington offshore waters detected Cuvier's beaked whale pulses between January and November 2011 (Ŝirović *et al.* 2012b *in* USN 2015). There is one sighting of a Cuvier's beaked whale near the proposed survey area in the OBIS database that was made in July 1996 during the SWFSC ORCAWALE Marine Mammal Survey (OBIS 2018), and several other sightings were made in adjacent waters, primarily to the south and east of the proposed survey area (Carretta *et al.* 2018; OBIS 2018). Cuvier's beaked whales were detected acoustically

in waters near the proposed survey area in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating *et al.* 2018).

There are no sightings of Blainville's beaked whales near the proposed survey area in the OBIS database (OBIS 2018). There is one sighting of an unidentified species of Mesoplodont whale near the survey area in the OBIS database that was made in July 1996 during the SWFSC ORCAWALE Marine Mammal Survey (OBIS 2018). There was one acoustic encounter with Blainville's beaked whales recorded in Quinault Canyon off Washington in waters 1400 m deep during 2011 (Baumann-Pickering *et al.* 2014). Blainville's beaked whales were not detected acoustically in waters near the proposed survey area in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating *et al.* 2018). Although Blainville's beaked whales could be encountered during the proposed survey, an encounter would be unlikely because the proposed survey area is beyond the northern limits of this tropical species' usual distribution.

Stejneger's beaked whale calls were detected during acoustic monitoring offshore Washington between January and June 2011, with an absence of calls from mid-July to November 2011 (Ŝirović *et al.* 2012b *in* USN 2015). Analysis of these data suggest that this species could be more than twice as prevalent in this area than Baird's beaked whale (Baumann-Pickering *et al.* 2014). Stejneger's beaked whales were also detected acoustically in waters near the proposed survey area in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating *et al.* 2018). There are no sightings of Stejneger's beaked whales near the proposed survey area in the OBIS database (OBIS 2018). There is one sighting of an unidentified species of *Mesoplodont* beaked whale near the survey area in the OBIS database that

was made during July 1996 during the SWFSC ORCAWALE Marine Mammal Survey (OBIS 2018).

Baird's beaked whale is sometimes seen close to shore where deep water approaches the coast, but its primary habitat is over or near the continental slope and oceanic seamounts (Jefferson *et al.* 2015). Along the U.S. West Coast, Baird's beaked whales have been sighted primarily along the continental slope (Green *et al.* 1992; Becker *et al.* 2012; Carretta *et al.* 2018) from late spring to early fall (Green *et al.* 1992). The whales move out from those areas in winter (Reyes 1991). In the eastern North Pacific Ocean, Baird's beaked whales apparently spend the winter and spring far offshore, and in June, they move onto the continental slope, where peak numbers occur during September and October. Green *et al.* (1992) noted that Baird's beaked whales on the U.S. West Coast were most abundant in the summer, and were not sighted in the fall or winter. MacLeod *et al.* (2006) reported numerous sightings and strandings of *Berardius* spp. off the U.S. West Coast.

Bottlenose Dolphin

During surveys off the U.S. West Coast, offshore bottlenose dolphins were generally found at distances greater than 1.86 miles (3 km) from the coast and were most abundant off southern California (Barlow, 2010, 2016). Based on sighting data collected by SWFSC during systematic surveys in the Northeast Pacific between 1986 and 2005, there were few sightings of offshore bottlenose dolphins north of about 40° N (Hamilton *et al.*, 2009). NMFS SWFSC developed a CCE habitat-based density model for bottlenose dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the

northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41ºN, but few records exist for Oregon/Washington (Carretta *et al.* 2017). Three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011 *in* USN 2015). It is possible that offshore bottlenose dolphins may range as far north as the proposed survey area during warm-water periods (Carretta *et al.* 2017). Adams *et al.* (2014) made one sighting off Washington during September 2012. There are no sightings of bottlenose dolphins near the proposed survey area in the OBIS database (OBIS 2018).

Striped Dolphin

Striped dolphin encounters increase in deep, relatively warmer waters off the U.S. West Coast, and their abundance decreases north of about 42°N (Barlow *et al.*, 2009; Becker *et al.*, 2012b; Becker *et al.*, 2016; Forney *et al.*, 2012). Although striped dolphins typically do not occur north of California, there are a few sighting records off Oregon and Washington (Barlow, 2003, 2010; Von Saunder & Barlow, 1999), and multiple sightings in 2014 when water temperatures were anomalously warm (Barlow, 2016). NMFS SWFSC developed a CCE habitat-based density model for striped dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Striped dolphins regularly occur off California (Becker *et al.* 2012), where they have been seen as far as the ~300 n.mi. limit during the NOAA Fisheries vessel surveys (Carretta *et al.* 2017). Strandings have occurred along the coasts of Oregon and Washington (Carretta *et al.* 2016). During surveys off the U.S. West Coast in 2014, striped dolphins were seen as far north as 44º N (Barlow 2016).

Short-beaked Common Dolphin

Short-beaked common dolphins are found off the U.S. West Coast throughout the year, distributed between the coast and at least 345 miles (556 km) from shore (Barlow, 2010; Becker *et al.*, 2017; Carretta *et al.*, 2017b). The short-beaked common dolphin is the most abundant cetacean species off California (Barlow, 2016; Carretta *et al.*, 2017b; Forney *et al.*, 1995); however, their abudance decreases dramatically north of about 40° N (Barlow *et al.*, 2009; Becker *et al.*, 2012c; Becker *et al.*, 2016; Forney *et al.*, 2012). Short-beaked common dolphins are occasionally sighted in waters off Oregon and Washington, and one group of approximately 40 short-beaked common dolphins was sighted off northern Washington in 2005 at about 48° N (Forney, 2007), and multiple groups were sighted as far north as 44° N during anomalously warm conditions in 2014 (Barlow, 2016). NMFS SWFSC developed a CCE habitat-based density model for short-beaked common dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

There are no sightings of short-beaked dolphins near the proposed survey area in the

OBIS database (OBIS 2018).

Pacific White-sided Dolphin

Pacific white-sided dolphins occur year-round in the offshore region of the NWTT Study

Area, with increased abundance in the summer/fall (Barlow, 2010; Forney & Barlow, 1998;

Oleson *et al.*, 2009). NMFS SWFSC developed a CCE habitat-based density model for Pacific

white-sided dolphins which provides spatially explicit density estimates off the U.S. West Coast

for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in*

prep). Density data are not available for the NWTT Offshore area northwest of the SWFSC

strata, so the habitat-based density values in the northernmost pixels adjoining this region were

interpolated based on the nearest-neighbor approach to provide representative density estimates

for this area.

Fifteen Pacific white-sided dolphin sightings (231 animals) were made off

Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey; none

were near the proposed survey area (RPS 2012b). There were fifteen Pacific white-sided dolphin

sightings (462 animals) made during the July 2012 L-DEO seismic surveys off southern

Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted

during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area

(RPS 2012c). One group of 10 Pacific white-sided dolphins was sighted during the 2009

ETOMO survey north of the proposed survey area (Holst 2017).

Northern Right Whale Dolphin

Survey data suggest that, at least in the eastern North Pacific, seasonal inshore-offshore

and north-south movements are related to prey availability, with peak abundance in the Southern

California Bight during winter and distribution shifting northward into Oregon and Washington as water temperatures increase during late spring and summer (Barlow, 1995; Becker *et al.*, 2014; Forney *et al.*, 1995; Forney & Barlow, 1998; Leatherwood & Walker, 1979). NMFS SWFSC developed a CCE habitat-based density model for northern right whale dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Seven northern right whale dolphin sightings (231 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey; none were seen near the proposed survey area (RPS 2012b). There were eight northern right whale dolphin sightings (278 animals) made during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c).

Risso's Dolphin

NMFS SWFSC developed a CCE habitat-based density model for Risso's dolphins which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Two sightings of 38 individuals were recorded off Washington from August 2004 to September 2008 (Oleson *et al.* 2009). Risso's dolphins were sighted off Oregon, in June and October 2011 (Adams *et al.* 2014). There were three Risso's dolphin sightings (31 animals) made during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c), or off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey (RPS 2012b).

False Killer Whale

False killer whales were not included in the NMSDD, as they are very rarely encountered in the northeast Pacific. Density estimates for false killer whales were also not presented in Barlow (2016), as no sightings occurred during surveys conducted between 1986 and 2008 (Ferguson and Barlow 2001, 2003; Forney 2007; Barlow 2003, 2010). One sighting was made off of southern California during 2014 (Barlow 2016). There are no sightings of false killer whales near the survey area in the OBIS database (OBIS 2018).

Killer Whale

Due to the difficulties associated with reliably distinguishing the different stocks of killer whales from at-sea sightings, density estimates for the Offshore region of the NWTT Study Area are presented for the species as a whole (*i.e.*, includes the Offshore, West Coast Transient, Northern Resident, and Southern Resident stocks). Density values for killer whales are available for the SWFSC Oregon/Washington and Northern California offshore strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the

SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. These values were used to represent density year-round.

Eleven sightings of ~536 individuals were reported off Oregon/Washington during the 2008 SWFSC vessel survey (Barlow 2010). Killer whales were sighted offshore Washington during surveys from August 2004 to September 2008 (Oleson *et al.* 2009). Keating *et al.* (2015) analyzed cetacean whistles from recordings made during 2000–2012; several killer whale acoustic detections were made offshore Washington.

Short-finned Pilot Whale

Along the U.S. West Coast, short-finned pilot whales were once common south of Point Conception, California (Carretta *et al.*, 2017b; Reilly & Shane, 1986), but now sightings off the U.S. West Coast are infrequent and typically occur during warm water years (Carretta *et al.*, 2017b). Stranding records for this species from Oregon and Washington waters are considered to be beyond the normal range of this species rather than an extension of its range (Norman *et al.*, 2004). Density values for short-finned pilot whales are available for the SWFSC Oregon/Washington and Northern California strata for summer/fall (Barlow, 2016). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so data from the SWFSC Oregon/Washington stratum were used as representative estimates. These values were used to represent density year-round.

Few sightings were made off California/ Oregon/Washington in 1984–1992 (Green *et al.* 1992; Carretta and Forney 1993; Barlow 1997), and sightings remain rare (Barlow 1997; Buchanan *et al.* 2001; Barlow 2010). No short-finned pilot whales were seen during surveys off Oregon and Washington in 1989–1990, 1992, 1996, and 2001 (Barlow 2003). A few sightings were made off California during surveys in 1991–2014 (Barlow 2010). Carretta *et al.* (2017)

reported one sighting off Oregon during 1991–2008. Several stranding events in Oregon/southern Washington have been recorded over the past few decades, including in March 1996, June 1998, and August 2002 (Norman *et al.* 2004).

Dall's Porpoise

NMFS SWFSC developed a CCE habitat-based density model for Dall's porpoise which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected between 1991 and 2014 (Becker *et al.*, *in prep*). Density data are not available for the NWTT Offshore area northwest of the SWFSC strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Oleson *et al.* (2009) reported 44 sightings of 206 individuals off Washington during surveys form August 2004 to September 2008. Dall's porpoise were seen in the waters off Oregon during summer, fall, and winter surveys in 2011 and 2012 (Adams *et al.* 2014). Nineteen Dall's porpoise sightings (144 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey; none were in near the proposed survey area (RPS 2012b). There were 16 Dall's porpoise sightings (54 animals) made during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c). Dall's porpoise was the most frequently sighted marine mammal species (5 sightings of 28 animals) during the 2009 ETOMO survey north of the proposed survey area (Holst 2017).

Northern Fur Seal

The Navy estimated the abundance of northern fur seals from the Eastern Pacific stock and the California breeding stock that could occur in the NWTT Offshore Study Area by determining the percentage of time tagged animals spent within the Study Area and applying that percentage to the population to calculate an abundance for adult females, juveniles, and pups independently on a monthly basis. Adult males are not expected to occur within the Offshore Study Area and the proposed survey area during the proposed geophysical survey as they spend the summer ashore at breeding areas in the Bering Sea and San Miguel Island (Caretta *et al.*, 2017b). Using the monthly abundances of fur seals within the Offshore Study Area, the Navy created strata to estimate the density of fur seals within three strata: 22 km to 70 km from shore, 70 km to 130 km from shore, and 130 km to 463 km from shore (the western Study Area boundary). L-DEO's proposed survey is 423 km from shore at the closest point. Based on satellite tag data and historic sealing records (Olesiuk 2012; Kajimura 1984), the Navy assumed 25 percent of the population present within the overall Offshore Study Area may be within the 130 km to 463 km stratum.

Thirty-one northern fur seal sightings (63 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey north of the proposed survey area (RPS 2012b). There were six sightings (6 animals) made during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c).

Guadalupe Fur Seal

As with northern fur seals, adult male Guadalupe fur seals are expected to be ashore at breeding areas over the summer, and are not expected to be present during the proposed

geophysical survey (Caretta *et al.*, 2017b; Norris 2017b). Additionally, breeding females are unlikely to be present within the Offshore Study Area as they remain ashore to nurse their pups through the fall and winter, making only short foraging trips from rookeries (Gallo-Reynoso *et al.*, 2008; Norris 2017b; Yochem *et al.*, 1987). To estimate the total abundance of Guadalupe fur seals, the Navy adjusted the population reported in the 2016 SAR (Caretta *et al.*, 2017b) of 20,000 seals by applying the average annual growth rate of 7.64 percent over the seven years between 2010 and 2017. The resulting 2017 projected abundance was 33,485 fur seals. Using the reported composition of the breeding population of Guadalupe fur seals (Gallo-Reynoso 1994) and satellite telemetry data (Norris 2017b), the Navy established seasonal and demographic abundances of fur seals expected to occur within the Offshore Study Area.

The distribution of Guadalupe fur seals in the Offshore Study Area was stratified by distance from shore (or water depth) to reflect their preferred pelagic habitat (Norris, 2017a). Ten percent of fur seals in the Study Area are expected to use waters over the continental shelf (approximated as waters with depths between 10 and 200 m). A depth of 10 m is used as the shoreward extent of the shelf (rather than extending to shore), because Guadalupe fur seals in the Offshore Study Area are not expected to haul out and would not be likely to come close to shore. All fur seals (*i.e.*, 100 percent) would use waters off the shelf (beyond the 200 m isobath) out to 300 km from shore, and 25 of percent of fur seals would be expected to use waters between 300 and 700 km from shore (including the proposed geophysical survey area). The second stratum (200 m to 300 km from shore) is the preferred habitat where Guadalupe fur seals are most likely to occur most of the time. Individuals may spend a portion of their time over the continental shelf or farther than 300 km from shore, necessitating a density estimate for those areas, but all Guadalupe fur seals would be expected to be in the central stratum most of the time, which is the

reason 100 percent is used in the density estimate for the central stratum (Norris, 2017a). Spatial areas for the three strata were estimated in a GIS and used to calculate the densities.

Guadalupe fur seals have not previously been observed in the proposed survey area, nor on previous L-DEO surveys off Washington and Oregon.

Northern Elephant Seal

The most recent surveys supporting the abundance estimate for northern elephant seals were conducted in 2010 (Caretta *et al.*, 2017b). By applying the average growth rate of 3.8 percent per year for the California breeding stock over the seven years from 2010 to 2017, the Navy calculated a projected 2017 abundance estimate of 232,399 elephant seals (Caretta *et al.*, 2017b; Lowry *et al.*, 2014). Male and female distributions at sea differ both seasonally and spatially. Pup counts reported by Lowry *et al.*, (2014) and life tables compiled by Condit *et al.*, (2014) were used to determine the proportion of males and females in the population, which was estimated to be 56 percent female and 44 percent male. Females are assumed to be at sea 100 percent of the time within their seasonal distribution area in fall and summer (Robinson *et al.*, 2012). Males are at sea approximately 90 percent of the time in fall and spring, remain ashore through the entire winter, and spend one month ashore to molt in the summer (*i.e.*, are at sea 66 percent of the summer). Monthly distribution maps produced by Robinson *et al.* (2012) showing the extent of foraging areas used by satellite tagged female elephant seals were used to estimate the spatial areas to calculate densities. Although the distributions were based on tagged female seals, Le Boeuf *et al.* (2000) and Simmons *et al.* (2007) reported similar tracks by males over broad spatial scales. The spatial areas representing each monthly distribution were calculating using GIS and then averaged to produce seasonally variable areas and resulting densities.

Off Washington, most elephant seal sightings at sea were made during June, July, and September; off Oregon, sightings were recorded from November through May (Bonnell *et al.* 1992). Several seals were seen off Oregon during summer, fall, and winter surveys in 2011 and 2012 (Adams *et al.* 2014). Northern elephant seals were also taken as bycatch off Oregon in the west coast groundfish fishery during 2002–2009 (Jannot *et al.* 2011). Northern elephant seals were sighted five times (5 animals) during the July 2012 L-DEO seismic surveys off southern Washington, northeast of the proposed survey area (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon, southeast of the proposed survey area (RPS 2012c), or off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey that included the proposed survey area (RPS 2012b). One northern elephant seal was sighted during the 2009 ETOMO survey north of the proposed survey area (Holst 2017).

Table 7. Marine Mammal Density Values in the Proposed Survey Area.

Species	Reported Density $(\#/km^2)^a$
LF Cetaceans	
Humpback whale	0.001829
Minke whale	0.0013
Sei whale	0.0004
Fin whale	0.004249
Blue whale	0.001096
MF Cetaceans	
Sperm whale	0.002561
Cuvier's and Mesoplodont beaked whales	0.007304
Baird's beaked whale	0.00082
Bottlenose dolphin	0.000003
Striped dolphin	0.009329
Short-beaked common dolphin	0.124891
Pacific white-sided dolphin	0.017426
Northern right-whale dolphin	0.039962
Risso's dolphin	0.007008

False killer whale	N/A
Killer whale	0.00092[b]
Short-finned pilot whale	0.00025
HF Cetaceans	
Kogia spp.	0.00163
Dall's porpoise	0.043951
Otariids	
Northern fur seal	0.0103[b]
Guadalupe fur seal	0.0029
Phocids	
Northern elephant seal	0.0309

[a] Navy 2018
[b] No stock-specific densities are available so densities are presumed equal for all stocks present

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate. In order to estimate the number of marine mammals predicted to be exposed to sound levels that would result in Level A or Level B harassment, radial distances from the airgun array to predicted isopleths corresponding to the Level A harassment and Level B harassment thresholds are calculated, as described above. Those radial distances are then used to calculate the area(s) around the airgun array predicted to be ensonified to sound levels that exceed the Level A and Level B harassment thresholds. The area estimated to be ensonified in a single day of the survey is then calculated (Table 8), based on the areas predicted to be ensonified around the array and representative trackline distances traveled per day. This number is then multiplied by the number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency. This results in an estimate of the total areas (km^2) expected to be ensonified to the Level A and Level B harassment thresholds.

Table 8. Areas (km^2) Estimated to be Ensonified to Level A and Level B Harassment Thresholds, per Day.

Survey	Criteria	Relevant	Daily	Total	25%	Total

		Isopleth (m)	Ensonified Area (km^2)	Survey Days	Increase	Ensonified Area (km^2)
2-D Survey	Level B Harassment					
	160-dB	6733	1346.90	3	1.25	5050.86
	Level A Harassment					
	LF Cetaceans	426.9	158.67	3	1.25	595.01
	HF Cetaceans	268.3	99.77	3	1.25	374.12
	Phocids	43.7	16.26	3	1.25	60.96
	MF Cetaceans	13.6	5.06	3	1.25	18.97
	Otariids	10.6	3.94	3	1.25	14.79
3-D Survey	Level B Harassment					
	160-dB	3758	690.52	16	1.25	13810.40
	Level A Harassment					
	LF Cetaceans	118.7	47.39	16	1.25	947.74
	HF Cetaceans	75.6	30.13	16	1.25	602.59
	Phocids	25.1	9.98	16	1.25	199.59
	MF Cetaceans	11.2	4.45	16	1.25	89.01
	Otariids	9.9	3.93	16	1.25	78.67

The marine mammals predicted to occur within these respective areas, based on estimated densities, are assumed to be incidentally taken. For species where take by Level A harassment has been requested, the calculated Level A takes have been subtracted from the total exposures within the Level B harassment zone. Estimated exposures for the proposed survey are shown in Table 9.

Table 9. Estimated Level A and Level B Exposures, and Percentage of Stock Exposed.

Species	Stock	Level B	Level A	Total Take	Percent of Stock
LF Cetaceans					
Humpback whale	California/Oregon/ Washington	32	3	35	1.21
Minke whale	California/Oregon/ Washington	23	2	25	3.93
Sei whale	Eastern North Pacific	7	1	8	1.54

Fin whale	California/Oregon/Washington	74	7	81	0.90
Blue whale	Eastern North Pacific	19	2	21	1.28
MF Cetaceans					
Sperm whale	California/Oregon/Washington	48	0	48	2.40
Cuvier's and Mesoplodont beaked whales	California/Oregon/Washington	138	0	138	2.18[a]
Baird's beaked whale	California/Oregon/Washington	15	0	15	0.56
Bottlenose dolphin	California/Oregon/Washington	13[b]	0	13[b]	0.68
Striped dolphin	California/Oregon/Washington	176	0	176	0.60
Short-beaked common dolphin	California/Oregon/Washington	2356	0	2356	0.24
Pacific white-sided dolphin	California/Oregon/Washington	329	0	329	1.23
Northern right-whale dolphin	California/Oregon/Washington	754	0	749	2.82
Risso's dolphin	California/Oregon/Washington	132	0	132	2.08
False killer whale	Hawaii Pelagic	5[b]	0	5[b]	0.32
Killer whale	Offshore	17	0	17	5.67[c]
	West Coast Transient				7.00[c]
Short-finned pilot whale	California/Oregon/Washington	18[b]	0	18[b]	2.15
HF Cetaceans					
Kogia spp.	California/Oregon/Washington	31	2	29	0.71
Dall's porpoise	California/Oregon/Washington	829	43	786	3.05
Otariids					
Northern fur seal	Eastern Pacific	194	0	194	0.03[c]
	California				1.38[c]
Guadalupe fur seal	Mexico	55	0	55	0.28
Phocids					
Northern elephant seal	California Breeding	583	0	583	0.33

[a] Combined stock abundances for Cuvier's beaked whales and Mesoplodont guild.
[b] Calculated take increased to mean group size (Barlow 2016).

[c] Where multiple stocks are affected, for the purposes of calculating the percentage of stock affected, takes are analyzed as if all takes occurred within each stock.

It should be noted that the proposed take numbers shown in Table 9 are expected to be conservative for several reasons. First, in the calculations of estimated take, 25 percent has been added in the form of operational survey days to account for the possibility of additional seismic operations associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate take as described above. Additionally, marine mammals would be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of takes by Level A harassment. However, the extent to which marine mammals would move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

Note that due to the different density estimates used, and in consideration of the near-field soundscape of the airgun array, we propose to authorize a different number of incidental takes than the number of incidental takes requested by L-DEO (see Table 6 in the IHA application).

Proposed Mitigation

In order to issue an IHA 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 impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses (latter not applicable for this action). NMFS regulations require applicants for incidental take authorizations to include information

about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)).

In evaluating how mitigation may or may not be appropriate to ensure the least practicable adverse impact on species or stocks and their habitat, as well as subsistence uses where applicable, we carefully consider two primary factors:

(1) the manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned); and

(2) the practicability of the measures for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

L-DEO has reviewed mitigation measures employed during seismic research surveys authorized by NMFS under previous incidental harassment authorizations, as well as recommended best practices in Richardson *et al.* (1995), Pierson *et al.* (1998), Weir and Dolman (2007), Nowacek *et al.* (2013), Wright (2014), and Wright and Cosentino (2015), and has incorporated a suite of proposed mitigation measures into their project description based on the above sources.

To reduce the potential for disturbance from acoustic stimuli associated with the activities, L-DEO has proposed to implement mitigation measures for marine mammals. Mitigation measures that would be adopted during the proposed surveys include (1) Vessel-based visual mitigation monitoring; (2) Vessel-based passive acoustic monitoring; (3) Establishment of an exclusion zone; (4) Power down procedures; (5) Shutdown procedures; (6) Ramp-up procedures; and (7) Vessel strike avoidance measures.

Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained observers (herein referred to as visual PSOs) to scan the ocean surface visually for the presence of marine mammals. The area to be scanned visually includes primarily the exclusion zone, but also the buffer zone. The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals that may enter the exclusion zone. During pre-clearance monitoring (*i.e.*, before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone would also prevent airgun operations from beginning (*i.e.* ramp-up). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 meter exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 meters). Visual monitoring of the exclusion zones and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance, and (2) during airgun use,

aid in establishing and maintaining the exclusion zone by alerting the visual observer and crew of marine mammals that are outside of, but may approach and enter, the exclusion zone.

L-DEO must use at least five dedicated, trained, NMFS-approved Protected Species Observers (PSOs). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.

At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration (*i.e.*, "high energy") seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator and ensure all PSO requirements per the IHA are met. To the maximum extent practicable, the experienced PSOs should be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most

appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

PSOs shall establish and monitor the exclusion and buffer zones. These zones shall be based upon the radial distance from the edges of the acoustic source (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source (*i.e.*, anytime airguns are active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) shall be communicated to the operator to prepare for the potential shutdown or powerdown of the acoustic source.

During use of the airgun (*i.e.*, anytime the acoustic source is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) should be communicated to the operator to prepare for the potential shutdown or powerdown of the acoustic source. Visual PSOs will immediately communicate all observations to the on duty acoustic PSO(s), including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals by crew members shall be relayed to the PSO team. During good conditions (*e.g.*, daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

Passive Acoustic Monitoring

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Acoustic monitoring means the use of trained personnel (sometimes referred to as passive acoustic monitoring (PAM) operators, herein referred to as acoustic PSOs) to operate PAM equipment to acoustically detect the presence of marine mammals. Acoustic monitoring involves acoustically detecting marine mammals regardless of distance from the source, as localization of animals may not always be possible. Acoustic monitoring is intended to further support visual monitoring (during daylight hours) in maintaining an exclusion zone around the sound source that is clear of marine mammals. In cases where visual monitoring is not effective (*e.g.*, due to weather, nighttime), acoustic monitoring may be used to allow certain activities to occur, as further detailed below.

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

The *R/V Langseth* will use a towed PAM system, which must be monitored by at a minimum one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties

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(acoustic and visual but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional two hours without acoustic monitoring during daylight hours only under the following conditions:

- Sea state is less than or equal to BSS 4;

- No marine mammals (excluding delphinids) detected solely by PAM in the applicable exclusion zone in the previous two hours;

- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

- Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of four hours in any 24-hour period.

Establishment of Exclusion and Buffer Zones

An exclusion zone (EZ) is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes, *e.g.,* auditory injury, disruption of critical behaviors. The PSOs would establish a minimum EZ with a 500 m radius for the 36 airgun array. The 500 m EZ would be based on radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within or enters this zone, the acoustic source would be shut down..

The 500 m EZ is intended to be precautionary in the sense that it would be expected to contain sound exceeding the injury criteria for all cetacean hearing groups, (based on the dual

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criteria of SELcum and peak SPL), while also providing a consistent, reasonably observable zone within which PSOs would typically be able to conduct effective observational effort. Additionally, a 500 m EZ is expected to minimize the likelihood that marine mammals will be exposed to levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that 500 m is likely regularly attainable for PSOs using the naked eye during typical conditions.

Pre-clearance and Ramp-up

Ramp-up (sometimes referred to as "soft start") means the gradual and systematic increase of emitted sound levels from an airgun array. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an array's airguns are active. Each stage should be approximately the same duration, and the total duration should not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone prior to the beginning of ramp-up. During pre-clearance is the only time observations of protected species in the buffer zone would prevent operations (*i.e.*, the beginning of ramp-up). The intent of ramp-up is to warn protected species of pending seismic operations and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the acoustic source. All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time should not be less than 60 minutes prior to

the planned ramp-up in order to allow the PSOs time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);

- Ramp-ups shall be scheduled so as to minimize the time spent with the source activated prior to reaching the designated run-in;

- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;

- Ramp-up may not be initiated if any marine mammal is within the applicable exclusion or buffer zone. If a marine mammal is observed within the applicable exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and 30 minutes for all other species);

- Ramp-up shall begin by activating a single airgun of the smallest volume in the array and shall continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration shall not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed;

- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon observation of a marine mammal within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation shall be communicated to the operator to prepare for the potential shutdown or powerdown;

- Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;

- If the acoustic source is shut down for brief periods (*i.e.*, less than 30 minutes) for reasons other than that described for shutdown and powerdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (*e.g.*, BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-clearance watch of 30 min is not required; and

- Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance of 30 min.

Shutdown and Powerdown

The shutdown of an airgun array requires the immediate de-activation of all individual airgun elements of the array while a powerdown requires immediate de-activation of all individual airgun elements of the array except the single 40-in^3 airgun. Any PSO on duty will have the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown and powerdown

commands are conveyed swiftly while allowing PSOs to maintain watch. When both visual and acoustic PSOs are on duty, all detections will be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. When the airgun array is active (*i.e.*, anytime one or more airguns is active, including during ramp-up and powerdown) and (1) a marine mammal appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinids, see below) is detected acoustically and localized within the applicable exclusion zone, the acoustic source will be shut down. When shutdown is called for by a PSO, the acoustic source will be immediately deactivated and any dispute resolved only following deactivation. Additionally, shutdown will occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) in the EZ. If the acoustic PSO cannot confirm presence within the EZ, visual PSOs will be notified but shutdown is not required.

Following a shutdown, airgun activity would not resume until the marine mammal has cleared the 500 m EZ. The animal would be considered to have cleared the 500 m EZ if it is visually observed to have departed the 500 m EZ, or it has not been seen within the 500 m EZ for 15 min in the case of small odontocetes and pinnipeds, or 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales.

The shutdown requirement can be waived for small dolphins in which case the acoustic source shall be powered down to the single 40-in^3 airgun if an individual is visually detected within the exclusion zone. As defined here, the small delphinoid group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the source vessel for purposes of interacting with the vessel and/or airgun array (*e.g.*, bow riding). This exception to the shutdown requirement would apply solely to specific genera of small dolphins —

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Tursiops, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Stenella and Steno — The acoustic source shall be powered down to 40-in^3 airgun if an individual belonging to these genera is visually detected within the 500 m exclusion zone.

Powerdown conditions shall be maintained until delphinids for which shutdown is waived are no longer observed within the 500 m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and may use best professional judgment in making this decision.

We include this small delphinoid exception because power-down/shutdown requirements for small delphinoids under all circumstances represent practicability concerns without likely commensurate benefits for the animals in question. Small delphinoids are generally the most commonly observed marine mammals in the specific geographic region and would typically be the only marine mammals likely to intentionally approach the vessel. As described above, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (*e.g.*, delphinids), as this group is relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (*i.e.*, permanent threshold shift).

A large body of anecdotal evidence indicates that small delphinoids commonly approach vessels and/or towed arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinoids (*e.g.*, Barkaszi *et al.*, 2012). The potential for increased shutdowns resulting from such a measure would require the Langseth to revisit the missed track line to reacquire data, resulting in an overall increase in the total sound energy input

to the marine environment and an increase in the total duration over which the survey is active in a given area. Although other mid-frequency hearing specialists (*e.g.*, large delphinoids) are no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, retaining a power-down / shutdown requirement for large delphinoids would not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. We do anticipate some benefit for a power-down / shutdown requirement for large delphinoids in that it simplifies somewhat the total range of decision-making for PSOs and may preclude any potential for physiological effects other than to the auditory system as well as some more severe behavioral reactions for any such animals in close proximity to the source vessel.

Powerdown conditions shall be maintained until the marine mammal(s) of the above listed genera are no longer observed within the exclusion zone, following which full-power operations may be resumed without ramp-up. Additionally, visual PSOs may elect to waive the powerdown requirement if the small dolphin(s) appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and may use best professional judgment in making this decision. Visual PSOs shall use best professional judgment in making the decision to call for a shutdown if there is uncertainty regarding identification (*i.e.*, whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived or one of the species with a larger exclusion zone). If PSOs observe any behaviors in a small delphinid for which shutdown is waived that indicate an adverse reaction, then powerdown will be initiated immediately.

Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (*i.e.*, animal is not required

to fully exit the buffer zone where applicable) or following 15 minutes for small odontocetes and 30 minutes for all other species with no further observation of the marine mammal(s).

Vessel Strike Avoidance

These measures apply to all vessels associated with the planned survey activity; however, we note that these requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. These measures include the following:

1.   Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A single marine mammal at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal to broad taxonomic group (*i.e.*, as a large whale or other marine mammal);

2.   Vessel speeds must be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel;

3.   All vessels must maintain a minimum separation distance of 100 m from large whales (*i.e.*, sperm whales and all baleen whales);

4.   All vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel; and

5.   When marine mammals are sighted while a vessel is underway, the vessel should take action as necessary to avoid violating the relevant separation distance (*e.g.*, attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel should reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

We have carefully evaluated the suite of mitigation measures described here and considered a range of other measures in the context of ensuring that we prescribe the means of effecting the least practicable adverse impact on the affected marine mammal species and stocks and their habitat. Based on our evaluation of the proposed measures, NMFS has preliminarily determined that the mitigation measures provide the means effecting the least practicable impact on the affected 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 IHA 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 authorizations 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 proposed action area. Effective reporting is critical both to compliance as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (*e.g.*, presence, abundance, distribution, density);

- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: (1) action or environment (*e.g.*, source characterization, propagation, ambient noise); (2) affected species (*e.g.*, life history, dive patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (*e.g.*, age, calving or feeding areas);

- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors;

- How anticipated responses to stressors impact either: (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks;

- Effects on marine mammal habitat (*e.g.*, marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat); and

- Mitigation and monitoring effectiveness.

Vessel-Based Visual Monitoring

As described above, PSO observations would take place during daytime airgun operations and nighttime start ups (if applicable) of the airguns. During seismic operations, at

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least five visual PSOs would be based aboard the *Langseth*. Monitoring shall be conducted in accordance with the following requirements:

- The operator shall provide PSOs with bigeye binoculars (*e.g.*, 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (*i.e.*, Fujinon or equivalent) solely for PSO use. These shall be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel;

- The operator will work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

PSOs must have the following requirements and qualifications:

- PSOs shall be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider;

- PSOs shall have no tasks other than to conduct observational effort (visual or acoustic), collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards);

- PSOs shall have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working;

- PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand;

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- NMFS must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (*i.e.*, experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating successful completion of the course;

- NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved;

- PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program;

- PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics; and

- The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver shall be submitted to NMFS and must include written justification. Requests shall be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

For data collection purposes, PSOs shall use standardized data collection forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel names (source vessel and other vessels associated with survey) and call signs;

- PSO names and affiliations;

- Dates of departures and returns to port with port name;

- Date and participants of PSO briefings;

- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

- Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

- Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (*e.g.*, vessel traffic, equipment malfunctions); and

- Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.*, pre-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

The following information should be recorded upon visual observation of any protected species:

- Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

- PSO who sighted the animal;

- Time of sighting;

- Vessel location at time of sighting;

- Water depth;

- Direction of vessel's travel (compass direction);

- Direction of animal's travel relative to the vessel;

- Pace of the animal;

- Estimated distance to the animal and its heading relative to vessel at initial sighting;

- Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

- Estimated number of animals (high/low/best);

- Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

- Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

- Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

- Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

- Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and

- Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.

If a marine mammal is detected while using the PAM system, the following information should be recorded:

- An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

- Date and time when first and last heard;

- Types and nature of sounds heard (*e.g.*, clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal); and

- Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

Reporting

A report would be submitted to NMFS within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report would also include estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations and including an estimate of those that were not detected, in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability.

L-DEO will be required to submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of protected species near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities). The draft report shall also include geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (*e.g.*, when the airguns began operating, when they

were turned off, or when they changed from full array to single gun or vice versa). GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the WGS84 geographic coordinate system. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the information submitted in interim monthly reports as well as additional data collected as described above and the IHA. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments on the draft report.

Reporting Injured or Dead Marine Mammals

In the event that personnel involved in survey activities covered by the authorization discover an injured or dead marine mammal, the L-DEO shall report the incident to the Office of Protected Resources (OPR), NMFS and to the NMFS West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

- Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

- Species identification (if known) or description of the animal(s) involved;

- Condition of the animal(s) (including carcass condition if the animal is dead);

- Observed behaviors of the animal(s), if alive;

- If available, photographs or video footage of the animal(s); and

- General circumstances under which the animal was discovered.

Additional Information Requests – If NMFS determines that the circumstances of any

marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

- Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

- If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 km) and immediately after the discovery of the stranding.

Examples of circumstances that could trigger the additional information request include, but are not limited to, the following:

- Atypical nearshore milling events of live cetaceans;

- Mass strandings of cetaceans (two or more individuals, not including cow/calf pairs);

- Beaked whale strandings;

- Necropsies with findings of pathologies that are unusual for the species or area; or

- Stranded animals with findings consistent with blast trauma.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must shall report the incident to OPR, NMFS and to regional stranding coordinators as soon as feasible. The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;

- Species identification (if known) or description of the animal(s) involved;

- Vessel's speed during and leading up to the incident;

- Vessel's course/heading and what operations were being conducted (if applicable);

- Status of all sound sources in use;

- Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

- Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

- Estimated size and length of animal that was struck;

- Description of the behavior of the marine mammal immediately preceding and following the strike;

- If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

- Estimated fate of the animal (*e.g.*, dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

- To the extent practicable, photographs or video footage of the animal(s).

Negligible Impact Analysis and Determination

NMFS has defined negligible impact 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 (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.*, population-level effects). An estimate of the number of takes alone is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS considers other factors, such as the likely nature of any responses (*e.g.*, intensity, duration), the context of any responses (*e.g.*, critical reproductive time or location, migration), as well as effects on habitat, and the likely effectiveness of the mitigation. We also assess the number, intensity, and context of estimated takes by evaluating this information relative to population status. Consistent with the 1989 preamble for NMFS's implementing regulations (54 FR 40338; September 29, 1989), the impacts from other past and ongoing anthropogenic activities are incorporated into this analysis via their impacts on the environmental baseline (*e.g.*, as reflected in the regulatory status of the species, population size and growth rate where known, ongoing sources of human-caused mortality, or ambient noise levels).

To avoid repetition, our analysis applies to all species listed in Tables 7 and 9, given that NMFS expects the anticipated effects of the proposed geophysical survey to be similar in nature. Where there are meaningful differences between species or stocks, or groups of species, in anticipated individual responses to activities, impact of expected take on the population due to differences in population status, or impacts on habitat, NMFS has identified species-specific factors to inform the analysis.

NMFS does not anticipate that serious injury or mortality would occur as a result of L-DEO's proposed survey, even in the absence of proposed mitigation. Thus the proposed authorization does not authorize any mortality. As discussed in the *Potential Effects* section, non-auditory physical effects, stranding, and vessel strike are not expected to occur.

We propose to authorize a limited number of instances of Level A harassment of seven species and Level B harassment of 26 marine mammal species. However, we believe that any PTS incurred in marine mammals as a result of the proposed activity would be in the form of only a small degree of PTS, not total deafness, and would be unlikely to affect the fitness of any individuals, because of the constant movement of both the *Langseth* and of the marine mammals in the project areas, as well as the fact that the vessel is not expected to remain in any one area in which individual marine mammals would be expected to concentrate for an extended period of time (*i.e.*, since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that marine mammals would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *Langseth's* approach due to the vessel's relatively low speed when conducting seismic surveys. We expect that the majority of takes would be in the form of short-term Level B behavioral harassment in the form of temporary avoidance of the area or decreased foraging (if such activity were occurring), reactions that are considered to be of low severity and with no lasting biological consequences (*e.g.*, Southall *et al.*, 2007). The proposed geophysical survey occurs outside of the U.S. EEZ and outside of any established Biologically Important Areas or critical habitat.

Potential impacts to marine mammal habitat were discussed previously in this document (see *Potential Effects of the Specified Activity on Marine Mammals and their Habitat*). Marine

mammal habitat may be impacted by elevated sound levels, but these impacts would be temporary. Prey species are mobile and are broadly distributed throughout the project areas; therefore, marine mammals that may be temporarily displaced during survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because of the relatively short duration (~19 days) and temporary nature of the disturbance, the availability of similar habitat and resources in the surrounding area, the impacts to marine mammals and the food sources that they utilize are not expected to cause significant or long-term consequences for individual marine mammals or their populations.

The activity is expected to impact a small percentage of all marine mammal stocks that would be affected by L-DEO's proposed survey (less than seven percent of all species). Additionally, the acoustic "footprint" of the proposed survey would be small relative to the ranges of the marine mammals that would potentially be affected. Sound levels would increase in the marine environment in a relatively small area surrounding the vessel compared to the range of the marine mammals within the proposed survey area.

The proposed mitigation measures are expected to reduce the number and/or severity of takes by allowing for detection of marine mammals in the vicinity of the vessel by visual and acoustic observers, and by minimizing the severity of any potential exposures via power downs and/or shutdowns of the airgun array. Based on previous monitoring reports for substantially similar activities that have been previously authorized by NMFS, we expect that the proposed mitigation will be effective in preventing at least some extent of potential PTS in marine mammals that may otherwise occur in the absence of the proposed mitigation.

The ESA-listed marine mammal species under our jurisdiction that are likely to be taken by the proposed surveys include the endangered sei, fin, blue, sperm, and Central America DPS

humpback whales, and the threatened Mexico DPS humpback whale and Guadalupe fur seal. We propose to authorize very small numbers of takes for these species relative to their population sizes. Given the low probability of fitness impacts to any individual, combined with the small portion of any of these stocks impacted, we do not expect population-level impacts to any of these species. The other marine mammal species that may be taken by harassment during the proposed survey are not listed as threatened or endangered under the ESA. With the exception of the northern fur seal, none of the non-listed marine mammals for which we propose to authorize take are considered "depleted" or "strategic" by NMFS under the MMPA.

NMFS concludes that exposures to marine mammal species and stocks due to L-DEO's proposed survey would result in only short-term (temporary and short in duration) effects to individuals exposed. Animals may temporarily avoid the immediate area, but are not expected to permanently abandon the area. Major shifts in habitat use, distribution, or foraging success are not expected. NMFS does not anticipate the proposed take estimates to impact annual rates of recruitment or survival.

In summary and as described above, the following factors primarily support our preliminary determination that the impacts resulting from this activity are not expected to adversely affect the species or stock through effects on annual rates of recruitment or survival:

No mortality is anticipated or authorized;

- The proposed activity is temporary and of relatively short duration (19 days);

- The anticipated impacts of the proposed activity on marine mammals would primarily be temporary behavioral changes due to avoidance of the area around the survey vessel;

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- The number of instances of PTS that may occur are expected to be very small in number. Instances of PTS that are incurred in marine mammals would be of a low level, due to constant movement of the vessel and of the marine mammals in the area, and the nature of the survey design (not concentrated in areas of high marine mammal concentration);

- The availability of alternate areas of similar habitat value for marine mammals to temporarily vacate the survey area during the proposed survey to avoid exposure to sounds from the activity;

- The potential adverse effects on fish or invertebrate species that serve as prey species for marine mammals from the proposed survey would be temporary and spatially limited; and

- The proposed mitigation measures, including visual and acoustic monitoring, power-downs, and shutdowns, are expected to minimize potential impacts to marine mammals.

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 proposed monitoring and mitigation measures, NMFS preliminarily finds that the total marine mammal take from the proposed activity will have a negligible impact on all affected marine mammal species or stocks.

Small Numbers

As noted above, only small numbers of incidental take may be authorized under Sections 101(a)(5)(A) and (D) of the MMPA for specified activities other than military readiness activities. The MMPA does not define small numbers and so, in practice, where estimated numbers are available, NMFS compares the number of individuals taken to the most appropriate estimation of abundance of the relevant species or stock in our determination of whether an

authorization is limited to small numbers of marine mammals. Additionally, other qualitative factors may be considered in the analysis, such as the temporal or spatial scale of the activities.

Table 9 provides the numbers of take by Level A and Level B harassment proposed for authorization, which are used herefor purposes of the small numbers analysis. The numbers of marine mammals that we propose for authorized take would be considered small relative to the relevant populations (less than seven percent for all species and stocks) for the species for which abundance estimates are available.

Based on the analysis contained herein of the proposed activity (including the proposed mitigation and monitoring measures) and the anticipated take of marine mammals, NMFS preliminarily finds that small numbers of marine mammals will be taken relative to the population size of the affected species or stocks.

Unmitigable Adverse Impact Analysis and Determination

There are no relevant subsistence uses of the affected marine mammal stocks or species implicated by this action. Therefore, NMFS has preliminarily determined that the total taking of affected species or stocks would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence purposes.

Endangered Species Act (ESA)

Section 7(a)(2) of the Endangered Species Act of 1973 (ESA: 16 U.S.C. 1531 *et seq.*) requires that each Federal agency insure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat. To ensure ESA compliance for the issuance of IHAs, NMFS consults internally, in this case with the ESA Interagency

Cooperation Division whenever we propose to authorize take for endangered or threatened species.

NMFS is proposing to authorize take of sei whales, fin whales, blue whales, sperm whales, Central America DPS humpback whales, Mexico DPS humpback whales and Guadalupe fur seals which are listed under the ESA. The Permit and Conservation Division has requested initiation of Section 7 consultation with the Interagency Cooperation Division for the issuance of this IHA. NMFS will conclude the ESA consultation prior to reaching a determination regarding the proposed issuance of the authorization.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to L-DEO for conducting a marine geophysical survey in the northeast Pacific Ocean in summer of 2019, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. A draft of the proposed IHA can be found at

https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act.

Request for Public Comments

We request comment on our analyses, the proposed authorization, and any other aspect of this Notice of Proposed IHA for L-DEO's proposed survey. We also request comment on the potential for renewal of this proposed IHA as described in the paragraph below. Please include with your comments any supporting data or literature citations to help inform our final decision on the request for MMPA authorization.

On a case-by-case basis, NMFS may issue a one-year IHA renewal with an expedited public comment period (15 days) when (1) another year of identical or nearly identical activities

as described in the Specified Activities section is planned or (2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the Dates and Duration section, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to expiration of the current IHA;

- The request for renewal must include the following:

(1) An explanation that the activities to be conducted under the proposed Renewal are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (*e.g.*, reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the Renewal); and

(2) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

Dated: June 3, 2019.

Donna S. Wieting,

Director, Office of Protected Resources,

National Marine Fisheries Service.

[FR Doc. 2019-12010 Filed: 6/7/2019 8:45 am; Publication Date: 6/10/2019]