DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

[RTID 0648–XR074]

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Marine Geophysical Survey 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 May 7, 2020.

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 (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 the 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 the takings are set forth.

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 plans to adopt the National Science Foundation's (NSF's) Environmental Assessment (EA), as we have preliminarily determined that it includes adequate information analyzing the effects on the human environment of issuing the IHA. NSF's EA is available at *https://www.nsf.gov/geo/oce/envcomp/.*

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 November 8, 2019, NMFS received a request from L–DEO for an IHA to take marine mammals incidental to a marine geophysical survey of the Cascadia Subduction Zone off the coasts of Washington, Oregon, and British Columbia, Canada. The application was deemed adequate and complete on March 6, 2020. L–DEO's request is for take of small numbers of 31 species of marine mammals by Level A and Level B harassment. Neither L–DEO nor NMFS expects serious injury or mortality to result from this activity and, therefore, an IHA is appropriate.

NMFS has previously issued IHAs to L–DEO for similar surveys in the northeast Pacific (*e.g.,* 84 FR 35073, July 22, 2019; 77 FR 41755, July 16, 2012). L–DEO complied with all the requirements (*e.g.,* mitigation, monitoring, and reporting) of the previous IHAs and information regarding their monitoring results may be found in the *Description of Marine Mammals in the Area of Specified Activities* section.

Description of Proposed Activity

Overview

Researchers from L–DEO, Woods Hole Oceanographic Institution (WHOI), and the University of Texas at Austin Institute of Geophysics (UTIG), with funding from the NSF, and in collaboration with researchers from Dalhousie University and Simon Fraser University (SFU) propose to conduct a high-energy seismic survey from the Research Vessel (R/V) *Marcus G Langseth* (*Langseth*) in the northeast Pacific Ocean beginning in June 2020. The seismic survey would be conducted at the Cascadia Subduction Zone off the coasts of Oregon, Washington, and

British Columbia, Canada. The proposed two-dimensional (2–D) seismic survey would occur within the Exclusive Economic Zones (EEZs) of Canada and the United States, including U.S. state waters and Canadian territorial waters. The survey would use a 36-airgun towed array with a total discharge volume of ~6,600 cubic inches (in^3) as an acoustic source, acquiring return signals using both a towed streamer as well ocean bottom seismometers (OBSs) and ocean bottom nodes (OBNs).

The proposed study would use 2–D seismic surveying and OBSs and OBNs to investigate the Cascadia Subduction Zone and provide data necessary to illuminate the depth, geometry, and physical properties of the seismogenic portion and updip extent of the megathrust zone between the subducting Juan de Fuca plate and the overlying accretionary wedge/North American plate. These data would provide essential constraints for earthquake and tsunami hazard assessment in this heavily populated region of the Pacific Northwest. The primary objectives of the survey proposed by researchers from L–DEO, WHOI, and UTIG is to characterize: (1) The deformation and topography of the incoming plate; (2) the depth, topography, and reflectivity of the megathrust; (3) sediment properties and amount of sediment subduction; and (4) the structure and evolution of the accretionary wedge, including geometry and reflectivity of fault networks, and how these properties vary along strike, spanning the full length of the margin and down dip across what may be the full width of the Cascadia Subduction Zone.

Dates and Duration

The proposed survey is expected to last for 40 days, with 37 days of seismic operations, 2 days of equipment deployment, and 1 day of transit. R/V *Langseth* would likely leave out of and return to port in Astoria, Oregon, during June–July 2020.

Specific Geographic Region

The proposed survey would occur within ~42–51° N, ~124–130° 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. The survey is proposed to occur within the EEZs of the United States and Canada, as well as in U.S. state waters and Canadian territorial waters, ranging in depth 60–4400 meters (m). A maximum of 6,890 km of transect lines would be surveyed. Most of the survey (63.2 percent) would occur in deep water (>1,000 m), 26.4 percent would occur in intermediate water (100–1,000 m deep), and 10.4 percent would take place in shallow water <100 m deep. Approximately 4 percent of the transect lines (295 km) would be undertaken in Canadian territorial waters (from 0–12 nautical miles (22.2 km) from shore), with most effort in intermediate waters. NMFS cannot authorize the incidental take of marine mammals in the territorial seas of foreign nations, as the MMPA does not apply in those waters. However, NMFS has still calculated the level of incidental take in the entire activity area (including Canadian territorial waters) as part of the analysis supporting our preliminary determination under the MMPA that the activity will have a negligible impact on the affected species.

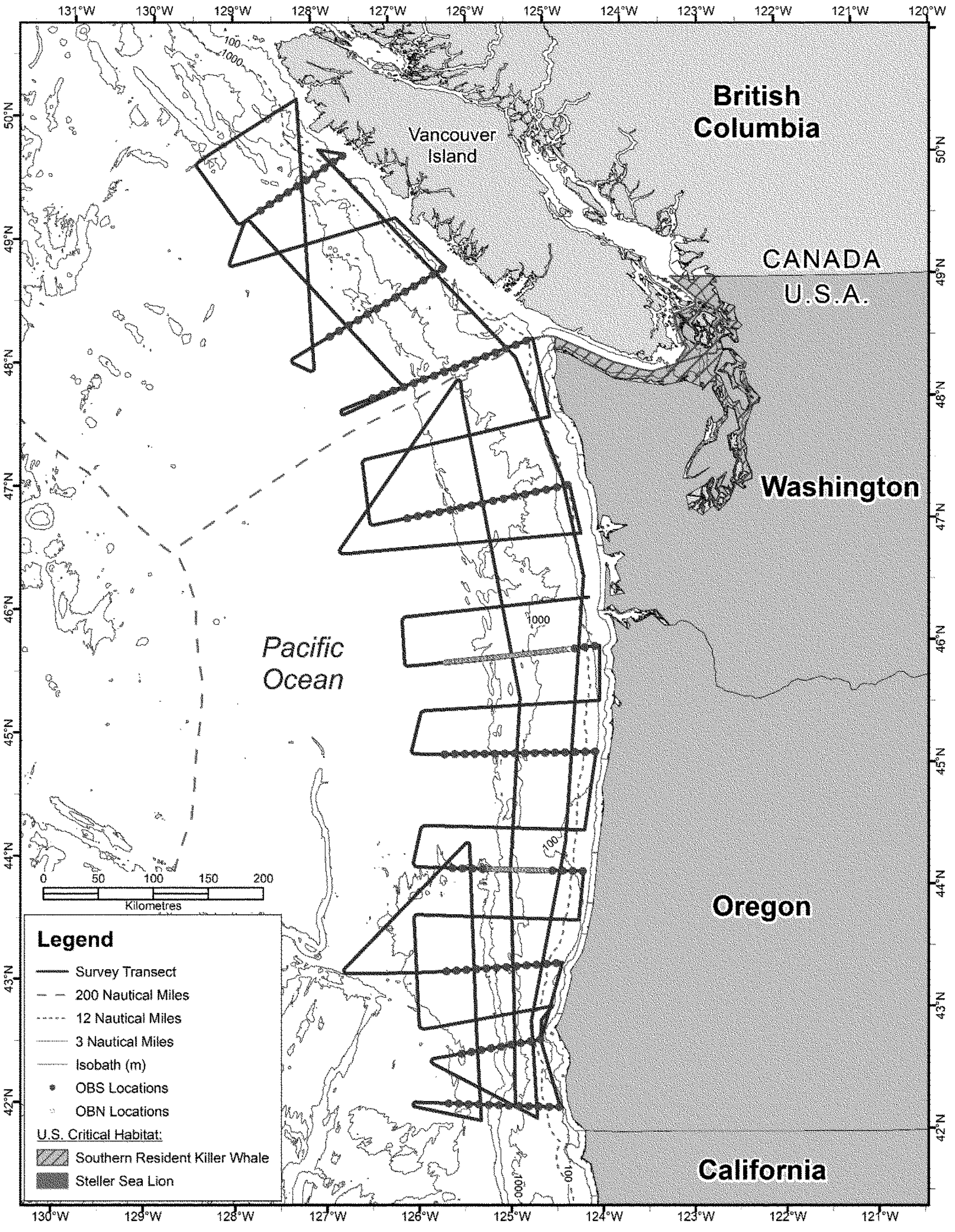

Figure 1. Location of the Proposed Seismic Survey in the Northeast Pacific Ocean

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 deploy an array of 36 airguns as an energy source with a total volume of ~6,600 in^3. The array consists of 20 Bolt 1500LL airguns with volumes of 180 to 360 in^3 and 16 Bolt 1900LLX airguns with volumes of 40 to 120 in^3. The airgun array configuration is illustrated in Figure 2–11 of NSF and USGS's Programmatic Environmental Impact Statement (PEIS; NSF–USGS, 2011). The vessel speed during seismic operations would be approximately 4.2 knots (~7.8 km/hour) during the survey and the airgun array would be towed at a depth of 12 m. The receiving system would consist of one 15-kilometer (km) long hydrophone streamer, OBSs, and OBNs. R/V *Oceanus,* which is owned by NSF and operated by Oregon State University, would be used to deploy the OBSs and OBNs. As the airguns are towed along the survey lines, the hydrophone streamer would transfer the data to the on-board processing system, and the OBSs and OBNs would receive and store the returning acoustic signals internally for later analysis.

Long 15-km-offset multichannel seismic (MCS) data would be acquired along numerous 2–D profiles oriented perpendicular to the margin and located to provide coverage in areas inferred to be rupture patches during past earthquakes and their boundary zones. The survey would also include several strike lines including one continuous line along the continental shelf centered roughly over gravity-inferred fore-arc basins to investigate possible segmentation near the down-dip limit of the seismogenic zone. The margin normal lines would extend ~50 km seaward of the deformation front to image the region of subduction bend faulting in the incoming oceanic plate, and landward of the deformation front to as close to the shoreline as can be safely maneuvered. It is proposed that the southern transects off Oregon are acquired first, followed by the profiles off Washington and Vancouver Island, British Columbia.

The OBSs would consist of short-period multi-component OBSs from the Ocean Bottom Seismometer Instrument Center (OBSIC) and a large-*N* array of OBNs from a commercial provider to record shots along ~11 MCS margin-perpendicular profiles. OBSs would be deployed at 10-km spacing along ~11 profiles from Vancouver Island to Oregon, and OBNs would be deployed at a 500-m spacing along a portion of two profiles off Oregon. Two OBS deployments would occur with a total of 115 instrumented locations. 60 OBSs would be deployed to instrument seven profiles off Oregon, followed by a second deployment of 55 OBSs to instrument four profiles off Washington and Vancouver Island. The first deployment off Oregon would occur prior to the start of the proposed survey, after which R/V *Langseth* would acquire data in the southern portion of the study area. R/V *Oceanus* would start recovering the OBSs from deployment 1, and then re-deploy 55 OBSs off Washington and Vancouver Island, so that R/V *Langseth* can acquire data in the northern portion of the survey area. The OBSs have a height and diameter of ~1 m, and an ~80 kilogram (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.

A total of 350 OBNs would be deployed: 229 nodes along one transect off northern Oregon, and 121 nodes along a second transect off central Oregon. The nodes are not connected to each other; each node is independent from each other, and there are no cables attached to them. Each node has internal batteries; all data is recorded and stored internally. The nodes weigh 21 kg in air (9.5 kg in water). As the OBNs are small (330 millimeters (mm) x 289 mm x 115 mm), compact, not buoyant, and lack an anchor-release mechanism, they cannot be deployed by free-fall as with the OBSs. The nodes would be deployed and retrieved using a remotely operated vehicle (ROV); the ROV would be deployed from R/V *Oceanus.* OBNs would be deployed 17 days prior to the start of the R/V *Langseth* cruise. The ROV would be fitted with a skid with capacity for 32 units, lowered to the seafloor, and towed at a speed of 0.6 knots at 5–10 m above the seafloor between deployment sites. After the 32 units are deployed, the ROV would be retrieved, the skid would be reloaded with another 32 units, and sent back to the seafloor for deployment, and so on. The ROV would recover the nodes 3 days after the completion of the R/V *Langseth* cruise. The nodes would be recovered one by one by a suction mechanism. Take of marine mammals is not expected to occur incidental to L–DEO's use of OBSs and OBNs.

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. Take of marine mammals is not expected to occur incidental to use of the MBES, SBP, or ADCP because they will be operated only during seismic acquisition, and it is assumed that, during simultaneous operations of the airgun array and the other sources, any marine mammals close enough to be affected by the MBES, SBP, and ADCP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, given their characteristics (*e.g.,* narrow downward-directed beam), marine mammals would experience no more than one or two brief ping exposures, if any exposure were to occur. 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 (2019). 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.,* 2019; Muto *et al.,* 2019). All MMPA stock information presented in Table 1 is the most recent available at the time of publication and is available in the 2018 SARs (Caretta *et al.,* 2019; Muto *et al.,* 2019) and draft 2019 SARs (available online at: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/draft-marine-mammal-stock-assessment-reports*). Where available, abundance and status information is also presented for marine mammals in Canadian waters in British Columbia.

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.
Family Balaenopteridae (rorquals):						
Humpback whale	*Megaptera novaeangliae*	California/Oregon/Washington.	-/-; Y	2,900 (0.05, 2,784, 2014)	16.7	>42.1.
		Central North Pacific	-/-; Y	10,103 (0.30, 7,891, 2006).	83	25.
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	>0.2.
Fin whale	*Balaenoptera physalus*	California/Oregon/Washington.	E/D; Y	9,029 (0.12, 8,127, 2014)	81	>2.0.
		Northeast Pacific	E/D; Y	3,168 (0.26, 2,554, 2013)	5.1	0.4.
Blue whale	*Balaenoptera musculus*	Eastern North Pacific	E/D; Y	1,496 (0.44, 1,050, 2014)	1.2	>19.4.
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)						
Family Physeteridae:						
Sperm whale	*Physeter macrocephalus*	California/Oregon/Washington.	E/D; Y	1,997 (0.57, 1,270, 2014)	2.5	0.4.
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.
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.
		British Columbia[4]	N/A	22,160 (unknown, 16,522, 2008).	Unknown	Unknown.
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*	N/A	N/A	N/A	N/A	N/A.
Killer whale	*Orcinus orca*	Offshore	-/-; N	300 (0.1, 276, 2012)	2.8	0.
		Southern Resident	E/D; Y	75 (N/A, 75, 2018)	0.13	0.
		Northern Resident	-/-; N	302 (N/A, 302, 2018)	2.2	0.2.
		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.
		Northern California/Southern Oregon.	-/-; N	35,769 (0.52, 23,749, 2011).	475	>0.6.
		British Columbia[4]	N/A	8,091 (unknown, 4,885, 2008).	Unknown	Unknown.
Dall's porpoise	*Phocoenoides dalli*	California/Oregon/Washington.	-/-; N	25,750 (0.45, 17,954, 2014).	172	0.3.
		British Columbia[4]	N/A	5,303 (unknown, 4,638, 2008).	Unknown	Unknown.

TABLE 1—MARINE MAMMALS THAT COULD OCCUR IN THE SURVEY AREA—Continued

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 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	399.
		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	>321.
Steller sea lion	*Eumetopias jubatus*	Eastern U.S.	-/-; N	43,201 (see SAR, 43,201, 2017).	2,592	113.
		British Columbia[4]	N/A	4,037 (unknown, 1,100, 2008).	Unknown	Unknown.
Guadalupe fur seal	*Arctocephalus philippii townsendi.*	Mexico to California	T/D; Y	34,187 (N/A, 31,019, 2013).	1,062	>3.8.
Family Phocidae (earless seals):						
Harbor seal	*Phoca vitulina*	Oregon/Washington Coastal.	-/-; N	Unknown (Unknown, Unknown, 1999).	Undetermined	10.6.
		British Columbia[4]	N/A	24,916 (Unknown, 19,666, 2008).	Unknown	Unknown.
Northern elephant seal.	*Mirounga angustirostris*	California Breeding	-/-; N	179,000 (N/A, 81,368, 2010).	4,882	8.8.

[1] Endangered Species Act (ESA) status: Endangered (E), Threatened (T)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

[2] NMFS marine mammal stock assessment reports online at: *https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments.* CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance. In some cases, CV is not applicable.

[3] These values, found in NMFS's SARs, represent annual levels of human-caused mortality plus serious injury from all sources combined (*e.g.,* commercial fisheries, ship strike). Annual M/SI often cannot be determined precisely and is in some cases presented as a minimum value or range. A CV associated with estimated mortality due to commercial fisheries is presented in some cases.

[4] Best *et al.* (2015) total abundance estimates for animals in British Columbia based on surveys of the Strait of Georgia, Johnstone Strait, Queen Charlotte Sound, Hecate Strait, and Dixon Entrance.

All species that could potentially occur in the proposed survey areas are included in Table 1. However, additional species have been recorded in the specified geographic region but are considered sufficiently rare that take is not anticipated. The temporal and/or spatial occurrence of North Pacific right whales (*Eubalaena japonica*) is such that take is not expected to occur, and they are not discussed further beyond the explanation provided here. Only 82 sightings of right whales in the entire eastern North Pacific were reported from 1962 to 1999, with the majority of these occurring in the Bering Sea and adjacent areas of the Aleutian Islands (Brownell *et al.,* 2001). Most sightings in the past 20 years have occurred in the southeastern Bering Sea, with a few in the Gulf of Alaska (Wade *et al.,* 2011). Despite many miles of systematic aerial and ship-based surveys for marine mammals off the coasts of Washington, Oregon and California over several years, only seven documented sightings of right whales were made from 1990 to 2000 (Waite *et al.,* 2003), and NMFS is not aware of any documented sightings in the area since then. Because of the small population size and the fact that North Pacific right whales spend the summer feeding in high latitudes, the likelihood that the proposed survey would encounter a North Pacific right whale is discountable.

In addition, the Northern sea otter (*Enhydra lutris kenyoni*) may be found in coastal waters of the survey area. However, sea otters are managed by the U.S. Fish and Wildlife Service and are not considered further in this document.

Gray Whale

Two separate populations for gray whales have been recognized in the North Pacific: The eastern North Pacific and the western North Pacific (or Korean-Okhotsk) stocks (LeDuc *et al.,* 2002; Weller *et al.,* 2013). However, the distinction between these two populations has been recently debated owing to evidence that whales from the western feeding area also travel to breeding areas in the eastern North Pacific (Weller *et al.,* 2012, 2013; Mate *et al.,* 2015). Thus it is possible that whales from either the ESA listed endangered Western North Pacific distinct population segment (DPS) or the delisted Eastern North Pacific DPS could occur in the survey area, although it is unlikely that a gray whale from the Western North Pacific DPS would be encountered during the time of the survey as they are expected to be in their feeding grounds in the western North Pacific at the time of the proposed survey. NMFS expects that any gray whales encountered by L–DEO during the proposed survey would be from the Eastern North Pacific DPS only, and is not proposing to authorize take of the endangered Western North Pacific DPS; therefore, the Western North Pacific DPS will not be discussed further in this document.

The eastern North Pacific gray whale breeds and winters in Baja California, and migrates north to summer feeding grounds in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971; Rice 1998; Jefferson *et al.,* 2015). The northward migration occurs from late February to June (Rice and Wolman 1971), with a peak in the Gulf of Alaska during mid-April (Braham 1984). Instead of migrating to arctic and sub-arctic waters, some individuals spend the summer months scattered along the coast from California to southeast Alaska (Rice and Wolman 1971; Nerini 1984; Darling *et al.,* 1998; Calambokidis and Quan 1999; Dunham and Duffus 2001, 2002; Calambokidis *et al.,* 2002, 2015, 2017). There is genetic evidence indicating the existence of this Pacific Coast Feeding Group (PCFG) is a distinct local subpopulation (Frasier *et al.,* 2011; Lang *et al.,* 2014) and the United States and Canada recognize it as such (COSEWIC 2017; Caretta *et al.,* 2019a). However, the status of the PCFG as a separate stock is currently unresolved (Weller *et al.,* 2013). For the purposes of abundance estimates, the PCFG is defined as occurring between 41° N to 52° N from June 1 to November 30 (IWC 2012). The 2015 abundance estimate for the PCFG was 243 whales (Calambokidis *et al.,* 2017); approximately 100 of those may occur in British Columbia during summer (Ford 2014). In British Columbia, most summer resident gray whales are found in Clayoquot Sound, Barkley Sound, and along the southwestern shore of Vancouver Island, and near Cape Caution on mainland British Columbia (Ford 2014). During surveys in British Columbia waters during summer, most sightings of gray whales were made within 10 km of shore and in water shallower than 100 m (Ford *et al.,* 2010a). Two sightings of three gray whales were seen from R/V *Northern Light* during a survey off southern Washington in July 2012 (RPS 2012a).

Biologically Important Areas (BIAs) for feeding gray whales along the coasts of Washington, Oregon, and California have been identified, including northern Puget Sound, Northwestern Washington, and Grays Harbor in Washington, Depoe Bay and Cape Blanco and Orford Reef in Oregon, and Point St. George in California; most of these areas are of importance from late spring through early fall (Calambokidis *et al.,* 2015). BIAs have also been identified for migrating gray whales along the entire coasts of Washington, Oregon, and California; although most whales travel within 10 km from shore, the BIAs were extended out to 47 km from the coastline (Calambokidis *et al.,* 2015). The proposed surveys would occur during the late spring/summer feeding season, when most individuals from the eastern North Pacific stock occur farther north. Nonetheless, individual gray whales, particularly those from the PCFG could be encountered in nearshore waters of the proposed project area.

On May 30, 2019, NMFS declared an unusual mortality event (UME) for gray whales after elevated numbers of strandings occurred along the U.S. west coast. As of February 8, 2020, a total of 236 stranded gray whales have been reported, including 124 in the United States (48 in Alaska, 35 in Washington, 6 in Oregon, and 35 in California), 101 in Mexico, and 11 in Canada. Full or partial necropsy examinations were conducted on a subset of the whales. Preliminary findings in several of the whales have shown evidence of emaciation. These findings are not consistent across all of the whales examined, so more research is needed. The UME is ongoing, and NMFS continues to investigate the cause(s). Additional information about the UME is available at *https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2020-gray-whale-unusual-mortality-event-along-west-coast.*

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). Humpback in the north Pacific 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).

Prior to 2016, humpback whales were listed under the ESA as an endangered species worldwide. Following a 2015 global status review (Bettridge *et al.,* 2015), NMFS established 14 distinct population segments (DPS) with different listing statuses (81 FR 62259; September 8, 2016) pursuant to the ESA. The DPSs that occur in U.S. waters do not necessarily equate to the existing stocks designated under the MMPA and shown in Table 1. Because MMPA stocks cannot be portioned, *i.e.,* parts managed as ESA-listed while other parts managed as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations, NMFS considers the existing humpback whale stocks under the MMPA to be endangered and depleted for MMPA management purposes (*e.g.,* selection of a recovery factor, stock status).

Within the proposed survey area, three current DPSs may occur: The Hawaii DPS (not listed), Mexico DPS (threatened), and Central America DPS (endangered). According to Wade *et al.* (2017), the probability that whales encountered in Oregon and California waters are from a given DPS are as follows: Mexico DPS, 32.7 percent; Central America DPS, 67.2 percent; Hawaii DPS, 0 percent. The probability that humpback whales encountered in Washington and British Columbia waters are as follows: Mexico DPS, 27.9 percent; Central America DPS, 8.7 percent; Hawaii DPS, 63.5 percent.

Humpback whales are 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. 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; Barlow 2016). Six humpback whale sightings (8 animals) were made off Washington/Oregon during the June–July 2012 L–DEO Juan de Fuca plate seismic survey. There were 98 humpback whale sightings (213 animals) made during the July 2012 L–DEO seismic survey off southern Washington (RPS 2012a), and 11 sightings (23 animals) during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c).

Humpback whales are common in the waters of British Columbia, where they occur in inshore, outer coastal, and continental shelf waters, as well as offshore (Ford 2014). Williams and Thomas (2007) estimated an abundance of 1,310 humpback whales in inshore coastal waters of British Columbia based on surveys conducted in 2004 and 2005. Best *et al.* (2015) provided an estimate of 1,029 humpbacks in British Columbia based on surveys during 2004–2008. In British Columbia, humpbacks are typically seen within 20 km from the coast, in water less than 500 m deep (Ford *et al.,* 2010a). The greatest numbers of humpbacks are seen in British Columbia between April and November, although humpbacks are known to occur there throughout the year (Ford *et al.,* 2010a; Ford 2014). Humpback whales in British Columbia are thought to belong to at least two distinct feeding stocks; those identified off southern British Columbia show little interchange with those seen off northern British Columbia (Calambokidis *et al.,* 2001, 2008). Humpback whales identified in southern British Columbia show a low level of interchange with those seen off California/Oregon/Washington (Calambokidis *et al.,* 2001).

BIAs for feeding humpbacks along the coasts of Oregon and Washington, which have been described from May to November, are all within approximately 80 km from shore, and include the waters off northern Washington, and Stonewall and Heceta Bank, Oregon (Calambokidis *et al.,* 2015). On October 9, 2019, NMFS issued a proposed rule to designate critical habitat in nearshore waters of the North Pacific Ocean for the endangered Central America DPS and the threatened Mexico DPS of humpback whale (NMFS 2019b). Critical habitat for the Central America DPS and Mexico DPS was proposed within the California Current Ecosystem (CCE) off the coasts California, Oregon, and Washington, representing areas of key foraging habitat. Off Washington and northern Oregon, the critical habitat would extend from the 50-m isobath out to the 1200-m isobath; off southern Oregon (south of 42°10′ N), it would extend out to the 2000-m isobath (NMFS 2019b).

Critical habitat for humpbacks has been designated in four locations in British Columbia (DFO 2013), including in the waters of the proposed survey area off southwestern Vancouver Island. The other three locations are located north of the proposed survey area at Haida Gwaii (Langara Island and Southeast Moresby Island) and at Gil Island (DFO 2013). These areas show persistent aggregations of humpback whales and have features such as prey availability, suitable acoustic environment, water quality, and physical space that allow for feeding, foraging, socializing, and resting (DFO 2013). Two of the proposed transect lines intersect the critical habitat on Swiftsure and La Pérouse Banks.

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 2° 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 180° N, 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 west coast of the United States (Dorsey *et al.* 1990).

Sightings of minke whales have been reported off Oregon and Washington in shelf and deeper waters (Green *et al.,* 1992; Adams *et al.,* 2014; Barlow 2016; Caretta *et al.,* 2019a). 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 (RPS 2012b,c). One minke whale was seen during the July 2012 L–DEO seismic survey off southern Washington (RPS 2012a). Minke whales are sighted regularly in nearshore waters of British Columbia, but they are not considered abundant (COSEWIC 2006). They are most frequently sighted around the Gulf Islands and off northeastern Vancouver Island (Ford 2014). They are also regularly seen off the east coast of Moresby Island, and in Dixon Entrance, Hecate Strait, Queen Charlotte Sound, and the west coast of Vancouver Island were they occur in shallow and deeper water (Ford *et al.,* 2010a; Ford 2014). Williams and Thomas (2007) estimated minke whale abundance for inshore coastal waters of British Columbia at 388 individuals based on surveys conducted in 2004 and 2005 while Best *et al.* (2015) provided an estimate of 522 minke whales based on surveys during 2004–2008.

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).

Sei whales are rare in the waters off California, Oregon, and Washington (Brueggeman *et al.,* 1990; Green *et al.,* 1992; Barlow 1994, 1997). Less than 20 confirmed sightings were reported in that region during extensive surveys between 1991 and 2014 (Green *et al.,* 1992, 1993; Hill and Barlow 1992; Caretta and Forney 1993; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow 2003, 2010, 2014; Forney 2007; Carretta *et al.,* 2019a). 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). No sei whales were sighted during the July 2012 L–DEO seismic surveys off Oregon and Washington (RPS 2012a,c).

The patterns of seasonal abundance found in whaling records suggested that the whales were caught as they migrated to summer feeding grounds, with the peak of the migration in July and offshore movement in summer, from ~25 km to ~100 km from shore (Gregr *et al.,* 2000). Historical whaling data show that sei whales used to be distributed along the continental slope of British Columbia and over a large area off the northwest coast of Vancouver Island (Gregr and Trites 2001). Sei whales are now considered rare in Pacific waters of the United States and Canada; in British Columbia there were no sightings in the late 1900s after whaling ceased (Gregr *et al.,* 2006). Ford (2014) only reported two sightings for British Columbia, both of those far offshore from Haida Gwaii. Possible sei whale vocalizations were detected off the west coast of Vancouver Island during spring and summer 2006 and 2007 (Ford *et al.,* 2010b). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for sei whales because of favorable feeding conditions.

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 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).

Eight fin whale sightings (19 animals) were made off Washington/Oregon during the June–July 2012 L–DEO Juan de Fuca plate seismic survey; sightings were made in waters 2,369–3,940 m deep (RPS 2012b). Fourteen fin whale sightings (28 animals) were made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a). No fin whales were sighted during the July 2012 L–DEO seismic survey off Oregon (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).

Whaling records indicate fin whale occurrence off the west coast of British Columbia increased gradually from March to a peak in July, then decreased rapidly in September and October (Gregr *et al.,* 2000). Fin whales occur throughout British Columbia waters near and past the continental shelf break, as well as in inshore waters (Ford 2014). Fin whales were the second most common cetacean sighted during DFO surveys in 2002–2008 (Ford *et al.,* 2010a). They appear to be more common in northern British Columbia, but sightings have been made along the shelf edge and in deep waters off western Vancouver Island (Ford *et al.,* 1994, 2010a; Calambokidis *et al.,* 2003; Ford 2014). Acoustic detections have been made throughout the year in pelagic waters west of Vancouver Island (Edwards *et al.,* 2015). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for fin whales because of favorable feeding conditions.

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 are considered rare off Oregon, Washington, and British Columbia (Buchanan *et al.,* 2001; Gregr *et al.,* 2006; Ford 2014), although satellite-tracked individuals have been reported off the coast (Bailey *et al.,* 2009). Based on modeling of the dynamic topography of the region, blue whales could occur in relatively high densities off Oregon during summer and fall (Pardo *et al.,* 2015: Hazen *et al.,* 2017). 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).

Sightings of blue whales in offshore waters of British Columbia are rare (Ford 2014; DFO 2017) and there is no abundance estimate for British Columbia waters (Nichol and Ford 2012). During surveys of British Columbia from 2002–2013, 16 sightings of blue whales were made, all of which occurred just to the south or west of Haida Gwaii during June, July, and August (Ford 2014). There have also been sightings off Vancouver Island during summer and fall (Calambokidis *et al.,* 2004b; Ford 2014), with the most recent one reported off southwestern Haida Gwaii in July 2019 (CBC 2019).

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). Sperm whales were sighted during surveys off Oregon in October 2011 and off Washington in June 2011 (Adams *et al.,* 2014). Sperm whale sightings were also made off Oregon and Washington during the 2014 SWFSC vessel survey (Barlow 2016). A single sperm whale was sighted during a 2009 survey to the west of the proposed survey area (Holst 2017).

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 (Ŝirović *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).

Whaling records report large numbers of sperm whales taken in April, with a peak in May. Analysis of data on catch locations, sex of the catch, and fetus lengths indicated that males and females were both 50–80 km from shore while mating in April and May, and that by July and August, adult females had moved to waters >100 km offshore to calve), and adult males had moved to within ~25 km of shore (Gregr *et al.,* 2000). At least in the whaling era, females did not travel north of Vancouver Island whereas males were observed in deep water off Haida Gwaii (Gregr *et al.,* 2000). After the whaling era, sperm whales have been sighted and detected acoustically in British Columbia waters throughout the year, with a peak during summer (Ford 2014). Acoustic detections at La Pérouse Bank off southwestern Vancouver Island have been recorded during spring and summer (Ford *et al.,* 2010b). Sightings west of Vancouver Island and Haida Gwaii indicate that this species still occurs in British Columbia in small numbers (Ford *et al.,* 1994; Ford 2014). Based on whaling data, Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for male sperm whales because of favorable feeding conditions.

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).

Pygmy and dwarf sperm whales are rarely sighted off Oregon and Washington, with only one sighting of an unidentified *Kogia* spp. beyond the U.S. EEZ, during the 1991–2014 NOAA vessel surveys (Carretta *et al.,* 2019a). 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. There are several unconfirmed sighting reports of the pygmy sperm whale from the Canadian west coast (Baird *et al.,* 1996). There is a stranding record of a pygmy sperm whale for northeastern Vancouver Island (Ford 2014), and there is a single dwarf sperm whale stranding record for southwestern Vancouver Island in September 1981 (Ford 2014). Willis and Baird (1998) state that the dwarf sperm whale is likely found in British Columbia waters more frequently than recognized, but Ford (2014) suggested that the presence of *Kogia* spp. in British Columbia waters is extralimital.

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). Records of Cuvier's beaked whale in British Columbia are scarce, although 20 strandings, one incidental catch, and five sightings have been reported, including off western Vancouver Island (Ford 2014). Most strandings have been reported in summer (Ford 2014).

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). Two forms of Baird's beaked whales have been recognized, the common slate-gray form and a smaller, rare black form (Morin *et al.,* 2017). The gray form is seen off Japan, in the Aleutians, and on the west coast of North America, whereas the black form has been reported for northern Japan and the Aleutians (Morin *et al.,* 2017). Recent genetic studies suggest that the black form could be a separate species (Morin *et al.,* 2017). Baird's beaked whales are currently divided into three distinct stocks: Sea of Japan, Okhotsk Sea, and Bering Sea/eastern North Pacific (Balcomb 1989; Reyes 1991). Baird's beaked whales are occasionally seen close to shore, but their primary habitat is in waters 1,000–3,000 m deep (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; Caretta *et al.,* 2019a) from late spring to early fall (Green *et al.,* 1992). In the eastern North Pacific, Baird's beaked whales apparently spend the winter and spring far offshore, and in June move onto the continental slop, 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.

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 (Ŝirović *et al.* 2012b *in* USN 2015). Baird's beaked whales were detected acoustically near the planned survey area in August 2016 during a SWFSC study using drifting acoustic recorders (Keating *et al.* 2018).

There are whaler's reports of Baird's beaked whales off the west coast of Vancouver Island throughout the whaling season (May–September), especially in July and August (Reeves and Mitchell 1993). Twenty-four sightings have been made in British Columbia since the whaling era, including off the west coast of Vancouver Island (Ford 2014). Three strandings have also been reported, including one on northeastern Haida Gwaii and two on the west coast of Vancouver Island.

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). Blainville's beaked whale 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). There was one acoustic detection of Blainville's beaked whales recorded in Quinault Canyon off Washington in waters 1,400 m deep during 2011 (Baumann-Pickering *et al.,* 2014).

Hubbs' 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). There have been no confirmed live sightings of Hubb's beaked whales in British Columbia.

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). Stejneger's beaked whale calls were detected during acoustic monitoring off of Washington between January and June 2011, with an absence of calls from mid-July through November 2011 (Ŝirović *et al.,* 2012b in Navy 2015). Analysis of these data suggest that this species could be more than twice as prevalent in this area as Baird's beaked whale (Baumann-Pickering *et al.,* 2014). At least five stranding records exist for British Columbia (Houston 1990b; Willis and Baird 1998; Ford 2014), including two strandings on the west coast of Haida Gwaii and two strandings on the west coast of Vancouver Island (Ford 2014). A possible sighting has been reported on the east coast of Vancouver Island (Ford 2014).

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).

Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41° N, but few records exist for Oregon and Washington (Caretta *et al.,* 2019a). Three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011 in Navy 2015). 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). Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41° N, but few records exist for Oregon/Washington (Carretta *et al.* 2017). It is possible that bottlenose dolphins from the California/Oregon/Washington Offshore stock may range as far north as the proposed survey area during warm-water periods (Caretta *et al.,* 2019a). Adams *et al.* (2014) recorded one sighting off Washington in September 2012. There are no confirmed records of bottlenose dolphins in British Columbia, though an unconfirmed record exists for offshore waters (Baird *et al.,* 1993).

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 43° 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).

Striped dolphins regularly occur off California (Becker *et al.,* 2012), including as far offshore as ~300 nmi (Caretta *et al.,* 2019a). 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). However, few sightings have been made off Oregon, and no sightings have been reported for Washington (Caretta *et al.,* 2019a) but strandings have occurred along the coasts of both Washington and Oregon (Caretta *et al.,* 2016). Striped dolphins are rare and considered extralimital in British Columbia (Ford 2014). There are a total of 14 confirmed records of stranded individuals or remains for Vancouver Island (Ford 2014). A single confirmed sighting was made in September 2019 in the Strait of Juan de Fuca (Pacific Whale Watch Association 2019).

Common Dolphin

The 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). Common dolphins have been sighted as far as 550 km from shore (Barlow *et al.* 1997).

The distribution of 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.). However, their abundance decreases dramatically north of about 40° N (Barlow *et al.,* 2009; Becker *et al.,* 2012c; Becker *et al.,* 2016; Forney *et al.,* 2012). Based on the absolute dynamic topography of the region, 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). There are three stranding records of common dolphins in British Columbia, including one from northwestern Vancouver Island, one from the Strait of Juan de Fuca, and one from Hecate Strait (Ford 2014).

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.

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 (RPS 2012b). There were fifteen Pacific white-sided dolphin sightings (462 animals) made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c). One group of 10 Pacific white-sided dolphins was sighted during the 2009 ETOMO survey (Holst 2017).

Pacific white-sided dolphins are common throughout the waters of British Columbia, including Dixon Entrance, Hecate Strait, Queen Charlotte Sound, the west coast of Haida Gwaii, as well as western Vancouver Island, and the mainland coast (Ford 2014). Stacey and Baird (1991a) compiled 156 published and unpublished records to 1988 of the Pacific white-sided dolphin within the Canadian 320-km extended EEZ. These dolphins move inshore and offshore seasonally (Stacey and Baird 1991a). There were inshore records for all months except July, and offshore records from all months except December. Offshore sightings were much more common than inshore sightings, especially in June–October; the mean water depth was ~1,100 m. Ford *et al.* (2011b) reported that most sightings occur in water depths <500 m and within 20 km from shore.

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).

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). 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 (RPS 2012b). There were eight northern right whale dolphin sightings (278 animals) made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c).

There are 47 records of northern right whale dolphins from British Columbia, mostly in deep water off the west coast of Vancouver Island; however, sightings have also been reported in deep water off Haida Gwaii (Ford 2014). Most sightings have occurred in water depths over 900 m (Baird and Stacey 1991a). One group of six northern right whale dolphins was seen west of Vancouver Island in water deeper than 2,500 m during a survey from Oregon to Alaska (Hauser and Holt 2009).

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° N (Jefferson *et al.,* 2014). Although it occurs from coastal to deep water (~200–1000 m depth), it shows a strong preference for mid-temperate waters of upper continental slopes and steep shelf-edge areas (Hartman 2018).

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 47°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 38° N; none were reported in Oregon/Washington (Barlow 2010).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 (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c), or off Washington/Oregon during the June–July 2012 L–DEO Juan de Fuca plate seismic survey (RPS 2012b).

Risso's dolphin was once considered rare in British Columbia, but there have been numerous sightings since the 1970s (Ford 2014). Most sightings have been made in Gwaii Haanas National Park Reserve, Haida Gwaii, but there have also been sightings in Dixon Entrance, off the west coast of Haida Gwaii, Queen Charlotte Sound, and to the west of Vancouver Island (Ford 2014).

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). It is widely distributed, but not abundant anywhere (Carwardine 1995). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow (Jefferson *et al.,* 2015; Baird 2018b). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2018b). 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 between 1930–2002, both in El Niño years (Norman *et al.* 2004). One sighting was made off southern California during 2014 (Barlow 2016).

Stacey and Baird (1991b) suggested that false killer whales are at the limit of their distribution in Canada and have always been rare. Sightings have been made along the northern and central mainland coast of British Columbia, as well as in Queen Charlotte Strait, Strait of Georgia, and along the west coast of Vancouver Island (Ford 2014).

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). There are three distinct ecotypes, or forms, of killer whales recognized in the north Pacific: Resident, transient, and offshore. The three ecotypes differ morphologically, ecologically, behaviorally, and genetically. Resident killer whales exclusively prey upon fish, with a clear preference for salmon (Ford and Ellis 2006; Hanson *et al.,* 2010; Ford *et al.,* 2016), while transient killer whales exclusively prey upon marine mammals (Caretta *et al.,* 2019). Less is known about offshore killer whales, but they are believed to consume primarily fish, including several species of shark (Dahlheim *et al.,* 2008).

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, Aleutian Islands, 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 Southern Resident, Northern Resident, West Coast Transient, and Offshore stocks could be encountered in the proposed project area. All three pods (J, K, and L pods) of Southern Resident killer whales may occur in the project area.

Southern Resident killer whales mainly feed on salmon, in particular Chinook (*Oncorhynchus tshawytscha*), but also prey upon other salmonids, such as chum (*O. keta*), coho (*O. kitsutch*), and steelhead (*O. mykiss*), as well as rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), Pacific herring (*Clupea pallasi*), among others. Seasonal and spatial shifts in prey consumption have been observed, with Chinook consumed in May through September, and chum eaten in the fall. Chinook remain an important prey item while the Southern Residents are in offshore coastal waters, where they also consume a greater diversity of fish species (NMFS 2019).

Southern Resident killer whales occur for part of the year in the inland waterways of the Salish Sea, including Puget Sound, the Strait of Juan de Fuca, and the southern Strait of Georgia mostly during the spring, summer, and fall. Their movement patterns appear related to the seasonal availability of prey, especially Chinook salmon. They also move to coastal waters, primarily off Washington and British Columbia, in search of suitable prey, and have been observed as far as central California and southeast Alaska (NMFS 2019). Although less is known about the whales' movements in outer coastal waters than inland waters of the Salish Sea, satellite tagging, opportunistic sighting, and acoustic recording data suggest that Southern Residents spend nearly all their time on the continental shelf, within 34 km of shore in water less than 200 m deep (Hanson *et al.,* 2017).

The Southern Resident DPS was listed as endangered under the ESA in 2005 after a nearly 20 percent decline in abundance between 1996 and 2001 (70 FR 69903; November 18, 2005). As compared to stable or growing populations, the DPS reflects lower fecundity and has demonstrated little to no growth in recent decades, and in fact has declined further since the date of listing (NMFS 2019). The population abundance listed in the draft 2019 SARs is 75, from the July 1, 2018 annual census conducted by the Center for Whale Research (CWR) (Caretta *et al.,* 2019); since that date, four whales have died or are presumed dead, and two calves were born in 2019, bringing the abundance to 73 whales (NMFS 2019). An additional adult male is considered missing as of January 2020 (CWR 2020). NMFS has identified three main causes of the population decline: (1) Reduced quantity and quality of prey; (2) persistent organic pollutants that could cause immune or reproductive system dysfunction; and (3) noise and disturbance from increased commercial and recreational vessel traffic (NMFS 2019).

The U.S. Southern Resident killer whale critical habitat designated under the ESA currently includes inland waters of Washington relative to a contiguous shoreline delimited by the line at a depth of 6.1 m relative to extreme high water (71 FR 69054; November 29, 2006). On September 19, 2019, NMFS published a proposed rule to revise designated Southern Resident killer whale critical habitat to include 40,472.7 km^2 of marine waters between the 6.1-m depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California (84 FR 49214; September 19, 2019). The proposed survey tracklines overlap with NMFS' proposed expanded Southern Resident critical habitat.

In Canada, Southern Resident killer whales are listed as Endangered under the Species at Risk Act (SARA), and critical habitat has been designated in the trans-boundary waters in southern British Columbia, including the southern Strait of Georgia, Haro Strait, and Strait of Juan de Fuca (SOR/2018–278, December 13, 2018; SOR/2009–68, February 19, 2009; DFO 2018). The continental shelf waters off southwestern Vancouver Island, including Swiftsure and La Pérouse Banks have also been designated as critical habitat (DFO 2018). Two of the proposed survey tracklines intersect the Canadian Southern Resident critical habitat on Swiftsure and La Pérouse Banks.

Northern Resident killer whales are not listed under the ESA, but are listed as threatened under Canada's SARA (DFO 2018). In British Columbia, Northern Resident killer whales inhabit the central and northern Strait of Georgia, Johnstone Strait, Queen Charlotte Strait, the west coast of Vancouver Island, and the entire central and north coast of mainland British Columbia (Muto *et al.,* 2019a,b). Northern Resident killer whales are also regularly acoustically detected off the coast of Washington (Hanson *et al.,* 2017). Canada has designated critical habitat for Northern Resident killer whales in Johnstone Strait, southeastern Queen Charlotte Strait, western Dixon Entrance along the north coast of Graham Island, Haida Gwaii, and Swiftsure and La Pérouse Banks off southwestern Vancouver Island (SOR/2018–278, December 13, 2018; SOR/2009–68, February 19, 2009; DFO 2018). Critical habitat for both Northern and Southern Resident killer whales has been established within the proposed survey area at Swiftsure and La Pérouse Banks (SOR/2018–278, December 13, 2018).

The main diet of transient killer whales consists of marine mammals, in particular porpoises and seals. West coast transient whales (also known as Bigg's killer whales) range from Southeast Alaska to California (Muto *et al.,* 2019a). The seasonal movements of transients are largely unpredictable, although there is a tendency to investigate harbor seal haulouts off Vancouver Island more frequently during the pupping season in August and September (Baird 1994; Ford 2014). Transients have been sighted throughout British Columbia waters, including the waters around Vancouver Island (Ford 2014).

Little is known about offshore killer whales, but they occur primarily over shelf waters and feed on fish, especially sharks (Ford 2014). Dalheim *et al.* (2008) reported sightings in southeast Alaska during spring and summer. Relatively few sightings of offshore killer whales have been reported in British Columbia; there have been 103 records since 1988 (Ford 2014). The number of sightings are likely influenced by the fact that these whales prefer deeper waters near the continental slope, where little sighting effort has taken place (Ford 2014). Most sightings are from Haida Gwaii and 15 km or more off the west coast of Vancouver Island near the continental slope (Ford *et al.,* 1994). Offshore killer whales are mainly seen off British Columbia during summer, but they can occur in British Columbia year-round (Ford 2014).

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 ~40° S and as far north as ~50° 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).

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.* (2019a) reported one sighting off Oregon during 1991–2014. 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).

Short-finned pilot whales are considered rare in British Columbia waters (Baird and Stacey 1993; Ford 2014). There are 10 confirmed records, including three bycatch records in offshore waters, six sightings in offshore waters, and one stranding; the stranding occurred in the Strait of Juan de Fuca (Ford 2014). There are also unconfirmed records for nearshore waters of western Vancouver Island (Baird and Stacey 1993; Ford 2014).

Harbor Porpoise

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore but is occasionally sighted in deeper offshore water (Jefferson *et al.,* 2015); abundance declines linearly as depth increases (Barlow 1988). In the eastern north Pacific, its range extends from Point Barrow, Alaska to Point Conception, California. Their seasonal movements appear to be inshore-offshore, rather than north-south, as a response to the abundance and distribution of food resources (Dohl *et al.,* 1983; Barlow 1988). Genetic testing has also shown that harbor porpoises along the west coast of North America are not migratory and occupy restricted home ranges (Rosel *et al.,* 1995).

Based on genetic data and density discontinuities, six stocks have been identified in California/Oregon/Washington: (1) Washington Inland Waters, (2) Northern Oregon/Washington Coast, (3) Northern California/Southern Oregon, (4) San Francisco-Russian River, (5) Monterey Bay, and (6) Morro Bay (Caretta *et al.,* 2019a). Harbor porpoises form the Northern Oregon/Washington and the Northern California/Southern Oregon stocks could occur in the proposed project area (Caretta *et al.,* 2019a).

Harbor porpoises inhabit coastal Oregon and Washington waters year-round, although there appear to be distinct seasonal changes in abundance there (Barlow 1988; Green *et al.,* 1992). Green *et al.* (1992) reported that encounter rates were similarly high during fall and winter, intermediate during spring, and low during summer. Encounter rates were highest along the Oregon/Washington coast in the area from Cape Blanco (~43° N) to California, from fall through spring. During summer, the reported encounter rates decreased notably from inner shelf to offshore waters. Green *et al.* (1992) reported that 96 percent of harbor porpoise sightings off Oregon/Washington occurred in coastal waters <100 m deep, with a few sightings on the slope near the 200-m isobath. Similarly, predictive density distribution maps show the highest in nearshore waters along the coasts of Oregon/Washington, with very low densities beyond the 500-m isobath (Menza *et al.,* 2016).

There were no harbor porpoise sightings made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a), the July 2012 L–DEO seismic survey off Oregon (RPS 2012c), or off Washington/Oregon during the June–July 2012 L–DEO Juan de Fuca plate seismic survey (RPS 2012b).

Harbor porpoises are found along the coast of British Columbia year-round, primarily in coastal shallow waters, harbors, bays, and river mouths (Osborne *et al.,* 1988), but can also be found in deep water over the continental shelf and over offshore banks that are no deeper than 150 m (Ford 2014; COSEWIC 2016). Many sightings records exist for nearshore waters of Vancouver Island, and occasional sightings have also been made in shallow water of Swiftsure and La Pérouse banks off southwestern Vancouver Island (Ford 2014).

Dall's Porpoise

Dall's porpoise is found in temperate to subarctic 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). Oleson *et al.* (2009) reported 44 sightings of 206 individuals off Washington during surveys from 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 (RPS 2012b). There were 16 Dall's porpoise sightings (54 animals) made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c).

Dall's porpoise is found all along the coast of British Columbia and is common inshore and offshore throughout the year (Jefferson 1990; Ford 2014). It is most common over the continental shelf and slope, but also occurs >2,400 km from the coast (Pike and MacAskie 1969 in Jefferson 1990), and sightings have been made throughout the proposed survey area (Ford 2014). During a survey from Oregon to Alaska, Dall's porpoises were sighted west of Vancouver Island and Haida Gwaii in early October during the southbound transit, but none were sighted in mid-September during the northward transit; all sightings were made in water deeper than 2000 m (Hauser and Holst 2009).

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 2008, individual adult females, subadult males, and between one and three pups have been observed annually on San Miguel Island (Caretta *et al.,* 2017).

During the summer breeding season, most adults occur at rookeries in Mexico (Caretta *et al.,* 2019a,b; Norris 2017 in Navy 2019a,b). Following the breeding season, adult males tend to move northward to forage. Females have been observed feeding south of Guadalupe Island, making an average round trip of 2,375 km (Ronald and Gots 2003). Several rehabilitated Guadalupe fur seals that were satellite tagged and released in central California traveled as far north as British Columbia (Norris *et al.,* 2015; Norris 2017 in Navy 2019a,b). Fur seals younger than two years old are more likely to travel to more northerly, offshore areas than older fur seals (Norris 2017 in Navy 2019a,b). Stranding data also indicates that fur seals younger than two years old are more likely to occur in the proposed survey area, as this age class was most frequently reported (Lambourn *et al.,* 2012 in Navy 2019a,b). Guadalupe fur seals have not been observed in previous L–DEO surveys in the northeast Pacific (RPS 2012a,b,c).

Increased strandings of Guadalupe fur seals have occurred along the entire coast of California. Guadalupe fur seal strandings began in January 2015 and were eight times higher than the historical average. Strandings have continued since 2015 and have remained well above average through 2019. Strandings are seasonal and generally peak in April through June of each year. Strandings in Oregon and Washington became elevated starting in 2019 and have continued to present. Strandings in these two states in 2019 are five times higher than the historical average. Guadalupe fur seals have stranded alive and dead. Those stranding are mostly weaned pups and juveniles (1–2 years old). The majority of stranded animals showed signs of malnutrition with secondary bacterial and parasitic infections. NMFS has declared a UME for Guadalupe fur seals along the entire U.S. West Coast; the UME is ongoing and NMFS is continuing to investigate the cause(s). For additional information on the UME, see *https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2020-guadalupe-fur-seal-unusual-mortality-event-california.*

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. The California stock originated with immigrants from the Pribilof Islands and Russian populations that recolonized San Miguel Island during the late 1950s or early 1960s after northern fur seals were extirpated from California in the 1700s and 1800s (DeLong 1982). The northern fur seal population appears to be greatly affected by El Niño events. In the month of June, approximately 93.6 percent of the northern fur seals in the survey area are expected to be from the Eastern Pacific stock and 6.4 percent from the California stock (U.S. Navy 2019). Therefore, although individuals from both the Eastern Pacific Stock and California Stock may be present in the proposed survey area, the majority are expected to be from the Eastern Pacific Stock.

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). Although pups may be present, there are no rookeries in Washington or Oregon.

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 survey area (Pelland *et al.* 2014).

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 (RPS 2012b). There were six sightings (6 animals) made during the July 2012 L–DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c).

Off British Columbia, females and subadult males are typically found during the winter off the continental shelf (Bigg 1990). They start arriving from Alaska during December and most will leave British Columbia waters by July (Ford 2014). Ford (2014) also reported the occurrence of northern fur seals throughout British Columbia, including Dixon Entrance, Hecate Strait, Queen Charlotte Sound, and off the west coasts of Haida Gwaii and Vancouver Island, with concentrations over the shelf and slope, especially on La Pérouse Bank, southwestern Vancouver Island. A few animals are seen in inshore waters in British Columbia, and individuals occasionally come ashore, usually at sea lion haulouts (*e.g.,* Race Rocks, off southern Vancouver Island) during winter and spring (Baird and Hanson 1997). Although fur seals sometimes haul out in British Columbia, there are no breeding rookeries.

Steller Sea Lion

The Steller sea lion occurs along the North Pacific Rim from northern Japan to California (Loughlin *et al.,* 1984). It is distributed around the coasts to the outer shelf from northern Japan through the Kuril Islands and Okhotsk Sea, through the Aleutian Islands, central Bering Sea, southern Alaska, and south to California (NOAA 2019d). There are two stocks and DPSs of Steller sea lions, the Western and Eastern DPSs, which are divided at 144° W longitude (Muto *et al.,* 2019b). The Western DPS is listed as endangered under the ESA and includes animals that occur in Japan and Russia (Muto *et al.,* 2019a,b); the Eastern DPS is not listed. Only individuals from the Eastern DPS are expected to occur in the proposed survey area.

Steller sea lions typically inhabit waters from the coast to the outer continental shelf and slope throughout their range; they are not considered migratory although foraging animals can travel long distances (Loughlin *et al.,* 2003; Raum-Suryan *et al.,* 2002). The eastern stock of Steller sea lions has historically bred on rookeries located in Southeast Alaska, British Columbia, Oregon, and California. However, within the last several years a new rookery has become established on the outer Washington coast (at the Carroll Island and Sea Lion Rock complex), with >100 pups born there in 2015 (Muto *et al.,* 2018). Breeding adults occupy rookeries from late-May to early-July (NMFS 2008). Federally designated critical habitat for Steller sea lions in Oregon and California includes all rookeries (NMFS 1993). Although the Eastern DPS was delisted from the ESA in 2013, the designated critical habitat remains valid (NOAA 2019e). The critical habitat in Oregon is located along the coast at Rogue Reef (Pyramid Rock) and Orford Reef (Long Brown Rock and Seal Rock). The critical habitat area includes aquatic zones that extend 0.9 km seaward and air zones extending 0.9 km above these terrestrial and aquatic zones (NMFS 1993).

Non-breeding adults use haulouts or occupy sites at the periphery of rookeries during the breeding season (NMFS 2008). Pupping occurs from mid-May to mid-July (Pitcher and Calkins 1981) and peaks in June (Pitcher *et al.,* 2002). Territorial males fast and remain on land during the breeding season (NMFS 2008). Females with pups generally stay within 30 km of the rookeries in shallow (30–120 m) water when feeding (NMFS 2008). Tagged juvenile sea lions showed localized movements near shore (Briggs *et al.,* 2005). Loughlin *et al.* (2003) reported that most (88 percent) at-sea movements of juvenile Steller sea lions were short (< 15 km) foraging trips. Although Steller sea lions are not considered migratory, foraging animals can travel long distances outside of the breeding season (Loughlin *et al.,* 2003; Raum-Suryan *et al.,* 2002). During the summer, they mostly forage within 60 km from the coast; during winter they can range up to 200 km from shore (Ford 2014).

During a survey off Washington/Oregon June–July 2012, two Steller sea lions were seen from R/V Langseth (RPS 2012b) off southern Oregon. Eight sightings of 11 individuals were made from R/V Northern Light during a survey off southern Washington during July 2012 (RPS 2012a).

In British Columbia there are six main rookeries which are situated at the Scott Islands off northwestern Vancouver Island, the Kerourd Islands near Cape St. James at the southern end of Haida Gwaii, North Danger Rocks in eastern Hecate Strait, Virgin Rocks in eastern Queen Charlotte Sound, Garcin Rocks off southeastern Moresby Island in Haida Gwaii, and Gosling Rocks on the central mainland coast (Ford 2014). The Scott Islands and Cape St. James rookeries are the two largest breeding sites with 4,000 and 850 pups born in 2010, respectively (Ford 2014). Some adults and juveniles are also found on sites known as year-round haulouts during the breeding season. Haulouts are located along the coasts of Haida Gwaii, the central and northern mainland coast, the west coast of Vancouver Island, and the Strait of Georgia; some are year-round sites whereas others are only winter haulouts (Ford 2014). Pitcher *et al.* (2007) reported 24 major haulout sites (>50 sea lions) in British Columbia, but there are currently around 30 (Ford 2014). The total pup and non-pup count of Steller sea lions in British Columbia in 2002 was 15,438; this represents a minimum population estimate (Pitcher *et al.,* 2007). The highest pup counts in British Columbia occur in July (Bigg 1988).

California Sea Lion

The primary range of the California sea lion includes the coastal areas and offshore islands of the eastern North Pacific Ocean from British Columbia to central Mexico, including the Gulf of California (Jefferson *et al.,* 2015). However, its distribution is expanding (Jefferson *et al.,* 2015), and its secondary range extends into the Gulf of Alaska (Maniscalco *et al.,* 2004) and southern Mexico (Gallo-Reynoso and Solórzano-Velasco 1991), where it is occasionally recorded.

In California and Baja California, births occur on land from mid-May to late-June. During August and September, after the mating season, the adult males migrate northward to feeding areas as far north as Washington (Puget Sound) and British Columbia (Lowry *et al.,* 1992). They remain there until spring (March-May), when they migrate back to the breeding colonies (Lowry *et al.,* Weise *et al.,* 2006). The distribution of immature California sea lions is less well known but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). However, most immature seals are presumed to remain near the rookeries for most of the year, as are females and pups (Lowry *et al.,* 1992). Peak numbers of California sea lions off Oregon and Washington occur during the fall (Bonnell *et al.,* 1992). California sea lions have not been observed in previous L–DEO surveys in the northeast Pacific (RPS 2012a,b,c).

California sea lions used to be rare in British Columbia, but their numbers have increased substantially since the 1970s and 1980s (Ford 2014). Wintering California sea lion numbers have increased off southern Vancouver Island since the 1970s, likely as a result of the increasing California breeding population (Olesiuk and Bigg 1984). Several thousand occur in the waters of British Columbia from fall to spring (Ford 2014). Adult and subadult male California sea lions are mainly seen in British Columbia during the winter (Olesiuk and Bigg 1984). They are mostly seen off the west coast of Vancouver Island and in the Strait of Georgia, but they are also known to haul out along the coasts of Haida Gwaii, including Dixon Entrance, and the mainland (Ford 2014).

Elevated strandings of California sea lion pups have occurred in Southern California since January 2013 and NMFS has declared a UME. The UME is confined to pup and yearling California sea lions, many of which are emaciated, dehydrated, and underweight for their age. A change in the availability of sea lion prey, especially sardines, a high value food source for nursing mothers, is a likely contributor to the large number of strandings. Sardine spawning grounds shifted further offshore in 2012 and 2013, and while other prey were available (market squid and rockfish), these may not have provided adequate nutrition in the milk of sea lion mothers supporting pups, or for newly-weaned pups foraging on their own. Although the pups showed signs of some viruses and infections, findings indicate that this event was not caused by disease, but rather by the lack of high quality, close-by food sources for nursing mothers. Current evidence does not indicate that this UME was caused by a single infectious agent, though a variety of disease-causing bacteria and viruses were found in samples from sea lion pups. Investigating and identifying the cause of this UME is a true public-private effort with many collaborators. The investigative team examined multiple potential explanations for the high numbers of malnourished California sea lion pups observed on the island rookeries and stranded on the mainland in 2013. The UME investigation is ongoing. For more information, see *https://www.fisheries.noaa.gov/national/marine-life-distress/2013-2017-california-sea-lion-unusual-mortality-event-california.*

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 45° 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).

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 (RPS 2012a). This species was not sighted during the July 2012 L–DEO seismic survey off Oregon (RPS 2012c), or off Washington/Oregon during the June–July 2012 L–DEO Juan de Fuca plate seismic survey (RPS 2012b). One northern elephant seal was sighted during the 2009 ETOMO survey off of British Columbia (Holst 2017).

Race Rocks Ecological Preserve, located off southern Vancouver Island, is one of the few spots in British Columbia where elephant seals regularly haul out. Based on their size and general appearance, most animals using Race Rocks are adult females or subadults, although a few males also haul out there. Use of Race Rocks by northern elephant seals has increased substantially in recent years, most likely as a result of the species' dramatic recovery from near extinction in the early 20th century and its tendency to be highly migratory. A peak number (22) of adults and subadults were observed in spring 2003 (Demarchi and Bentley 2004); pups have also been born there primarily during December and January (Ford 2014). Haulouts can also be found on the western and northeastern coasts of Haida Gwaii, and along the coasts of Vancouver Island (Ford 2014).

Harbor Seal

Two subspecies of harbor seal occur in the Pacific: *P.v. stejnegeri* in the northwest Pacific Ocean and *P.v. richardii* in the eastern Pacific Ocean. *P.v. richardii* occurs in nearshore, coastal, and estuarine areas ranging from Baja California, Mexico, north to the Pribilof Islands in Alaska (Carretta *et al.,* 2019a). Five stocks of harbor seals are recognized along the U.S. West Coast: (1) Southern Puget Sound, (2) Washington Northern Inland Waters Stock, (3) Hood Canal, (4) Oregon/Washington Coast, and (5) California (Carretta *et al.,* 2019a). The Oregon/Washington Coast stock occurs in the proposed survey area.

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally non-migratory, but move locally with the tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows; pups are born from May to mid-July. When molting, which occurs primarily in late August, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates. Juvenile harbor seals can travel significant distances (525 km) to forage or disperse (Lowry *et al.,* 2001). The smaller home range used by adults is suggestive of a strong site fidelity (Pitcher and Calkins 1979; Pitcher and McAllister 1981; Lowry *et al.,* 2001).

Harbor seals haul out on rocks, reefs, and beaches along the U.S. west coast (Carretta *et al.,* 2019a). Jeffries *et al.* (2000) documented several harbor seal rookeries and haulouts along the Washington coastline. Bonnell *et al.* (1992) noted that most harbor seals sighted off Oregon and Washington were within 20 km from shore, with the farthest sighting 92 km from the coast. Menza *et al.* (2016) also showed the highest predicted densities nearshore. During surveys off the Oregon and Washington coasts, 88 percent of at-sea harbor seals occurred over shelf waters <200 m deep, with a few sightings near the 2000-m contour, and only one sighting over deeper water (Bonnell *et *al.,* 1992). Twelve sightings of harbor seals occurred in nearshore waters from R/V *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a).

Harbor seals occur along all coastal areas of British Columbia, including the western coast of Vancouver Island, with the highest concentration in the Strait of Georgia (13.1 seals per km of coast); average densities elsewhere are 2.6 seals per km (Ford 2014). Almost 1,400 haulouts have been reported for British Columbia, many of them in the Strait of Georgia (Ford 2014).

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. 31 marine mammal species (25 cetacean and six pinniped (four otariid and two 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, six 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 four are classified as high-frequency cetaceans (*i.e.,* porpoises 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 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 $\mu Pa^2 - s$) 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. Note that, in the following discussion, we refer in many cases to a review article concerning studies of noise-induced hearing loss conducted from 1996–2015 (*i.e.,* Finneran, 2015). For study-specific citations, please see that work. 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, 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, 2019), Finneran and Jenkins (2012), Finneran (2015), and NMFS (2018).

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, 2019; 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 or amplitude of calls (Miller *et al.,* 2000; Fristrup *et al.,* 2003; Foote *et al.,* 2004; Holt *et al.,* 2012), 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 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 μPa^2-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).

Forney *et al.* (2017) detail the potential effects of noise on marine mammal populations with high site fidelity, including displacement and auditory masking, noting that a lack of observed response does not imply absence of fitness costs and that apparent tolerance of disturbance may have population-level impacts that are less obvious and difficult to document. As we discuss in describing our proposed mitigation later in this document, avoidance of overlap between disturbing noise and areas and/or times of particular importance for sensitive species may be critical to avoiding population-level impacts because (particularly for animals with high site fidelity) there may be a strong motivation to remain in the area despite negative impacts. Forney *et al.* (2017) state that, for these animals, remaining in a disturbed area may reflect a lack of alternatives rather than a lack of effects. The authors discuss several case studies, including western Pacific gray whales, which are a small population of mysticetes believed to be adversely affected by oil and gas development off Sakhalin Island, Russia (Weller *et al.,* 2002; Reeves *et al.,* 2005). Western gray whales display a high degree of interannual site fidelity to the area for foraging purposes, and observations in the area during airgun surveys has shown the potential for harm caused by displacement from such an important area (Weller *et al.,* 2006; Johnson *et al.,* 2007). Forney *et al.* (2017) also discuss beaked whales, noting that anthropogenic effects in areas where they are resident could cause severe biological consequences, in part because displacement may adversely affect foraging rates, reproduction, or health, while an overriding instinct to remain could lead to more severe acute effects.

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 in^3 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 respirations pre-, 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 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 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).

Southern Resident killer whales often forage in the company of whale watch boats in the waters around the San Juan Islands, Washington. These observed behavioral changes have included faster swimming speeds (Williams *et al.,* 2002b), less directed swimming paths (Williams *et al.,* 2002b; Bain *et al.,* 2006; Williams *et al.,* 2009a), and less time foraging (Bain *et al.,* 2006; Williams *et al.,* 2006; Lusseau *et al.,* 2009; Giles and Cendak 2010; Senigaglia *et al.,* 2016). Vessels in the path of the whales can also interfere with important social behaviors such as prey sharing (Ford and Ellis 2006) or nursing (Kriete 2007). Williams *et al.* (2006) found that with the disruption of feeding behavior that has been observed in Northern Resident killer whales, it is estimated that the presence of vessels could result in an 18 percent decrease in energy intake.

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.

Sounds emitted by the *Langseth* are low frequency and continuous, but would be widely dispersed in both space and time. Vessel traffic associated with the proposed survey is of low density compared to traffic associated with commercial shipping, industry support vessels, or commercial fishing vessels, and would therefore be expected to represent an insignificant incremental increase in the total amount of anthropogenic sound input to the marine environment, and the effects of vessel noise described above are not expected to occur as a result of this survey. 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* will travel at a speed of 4.2 kn (7.8 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 = $0\text{–}5.5 \times 10^{-6}$; 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 during transit. 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).

There is no conclusive evidence that exposure to airgun noise results in behaviorally-mediated forms of injury. Behaviorally-mediated injury (*i.e.,* mass stranding events) has been primarily associated with beaked whales exposed to mid-frequency active (MFA) naval sonar. Tactical sonar and the alerting stimulus used in Nowacek *et al.* (2004) are very different from the noise produced by airguns. One should therefore not expect the same reaction to airgun noise as to these other sources. As explained below, military MFA sonar is very different from airguns, and one should not assume that airguns will cause the same effects as MFA sonar (including strandings).

To understand why Navy MFA sonar affects beaked whales differently than airguns do, it is important to note the distinction between behavioral sensitivity and susceptibility to auditory injury. To understand the potential for auditory injury in a particular marine mammal species in relation to a given acoustic signal, the frequency range the species is able to hear is critical, as well as the species' auditory sensitivity to frequencies within that range. Current data indicate that not all marine mammal species have equal hearing capabilities across all frequencies and, therefore, species are grouped into hearing groups with generalized hearing ranges assigned on the basis of available data (Southall *et al.,* 2007, 2019). Hearing ranges as well as auditory sensitivity/susceptibility to frequencies within those ranges vary across the different groups. For example, in terms of hearing range, the high-frequency cetaceans (*e.g., Kogia* spp.) have a generalized hearing range of frequencies between 275 Hz and 160 kHz, while mid-frequency cetaceans—such as dolphins and beaked whales—have a generalized hearing range between 150 Hz to 160 kHz. Regarding auditory susceptibility within the hearing range, while mid-frequency cetaceans and high-frequency cetaceans have roughly similar hearing ranges, the high-frequency group is much more susceptible to noise-induced hearing loss during sound exposure, *i.e.,* these species have lower thresholds for these effects than other hearing groups (NMFS, 2018). Referring to a species as behaviorally sensitive to noise simply means that an animal of that species is more likely to respond to lower received levels of sound than an animal of another species that is considered less behaviorally sensitive. So, while dolphin species and beaked whale species—both in the mid-frequency cetacean hearing group—are assumed to (generally) hear the same sounds equally well and be equally susceptible to noise-induced hearing loss (auditory injury), the best available information indicates that a beaked whale is more likely to behaviorally respond to that sound at a lower received level compared to an animal from other mid-frequency cetacean species that are less behaviorally sensitive. This distinction is important because, while beaked whales are more likely to respond behaviorally to sounds than are many other species (even at lower levels), they cannot hear the predominant, lower frequency sounds from seismic airguns as well as sounds that have more energy at frequencies that beaked whales can hear better (such as military MFA sonar).

Navy MFA sonar affects beaked whales differently than airguns do because it produces energy at different frequencies than airguns. Mid-frequency cetacean hearing is generically thought to be best between 8.8 to 110 kHz, *i.e.,* these cutoff values define the range above and below which a species in the group is assumed to have declining auditory sensitivity, until reaching frequencies that cannot be heard (NMFS, 2018). However, beaked whale hearing is likely best within a higher, narrower range (20–80 kHz, with best sensitivity around 40 kHz), based on a few measurements of hearing in stranded beaked whales (Cook *et al.,* 2006; Finneran *et al.,* 2009; Pacini *et al.,* 2011) and several studies of acoustic signals produced by beaked whales (*e.g.,* Frantzis *et al.,* 2002; Johnson *et al.,* 2004, 2006; Zimmer *et al.,* 2005). While precaution requires that the full range of audibility be considered when assessing risks associated with noise exposure (Southall *et al.,* 2007, 2019a2019), animals typically produce sound at frequencies where they hear best. More recently, Southall *et al.* (2019a2019) suggested that certain species amongst the historical mid-frequency hearing group (beaked whales, sperm whales, and killer whales) are likely more sensitive to lower frequencies within the group's generalized hearing range than are other species within the group and state that the data for beaked whales suggest sensitivity to approximately 5 kHz. However, this information is consistent with the general conclusion that beaked whales (and other mid-frequency cetaceans) are relatively insensitive to the frequencies where most energy of an airgun signal is found. Military MFA sonar is typically considered to operate in the frequency range of approximately 3–14 kHz (D'Amico *et al.,* 2009), *i.e.,* outside the range of likely best hearing for beaked whales but within or close to the lower bounds, whereas most energy in an airgun signal is radiated at much lower frequencies, below 500 Hz (Dragoset, 1990).

It is important to distinguish between energy (loudness, measured in dB) and frequency (pitch, measured in Hz). In considering the potential impacts of mid-frequency components of airgun noise (1–10 kHz, where beaked whales can be expected to hear) on marine mammal hearing, one needs to account for the energy associated with these higher frequencies and determine what energy is truly ''significant.'' Although there is mid-frequency energy associated with airgun noise (as expected from a broadband source), airgun sound is predominantly below 1 kHz (Breitzke *et al.,* 2008; Tashmukhambetov *et al.,* 2008; Tolstoy *et al.,* 2009). As stated by Richardson *et al.* (1995), ''[. . .] most emitted [seismic airgun] energy is at 10–120 Hz, but the pulses contain some energy up to 500–1,000 Hz.'' Tolstoy *et al.* (2009) conducted empirical measurements, demonstrating that sound energy levels associated with airguns were at least 20 decibels (dB) lower at 1 kHz (considered ''mid-frequency'') compared to higher energy levels associated with lower frequencies (below 300 Hz) (''all but a small fraction of the total energy being concentrated in the 10–300 Hz range'' [Tolstoy *et al.,* 2009]), and at higher frequencies (*e.g.,* 2.6–4 kHz), power might be less than 10 percent of the peak power at 10 Hz (Yoder, 2002). Energy levels measured by Tolstoy *et al.* (2009) were even lower at frequencies above 1 kHz. In addition, as sound propagates away from the source, it tends to lose higher-frequency components faster than low-frequency components (*i.e.,* low-frequency sounds typically propagate longer distances than high-frequency sounds) (Diebold *et al.,* 2010). Although higher-frequency components of airgun signals have been recorded, it is typically in surface-ducting conditions (*e.g.,* DeRuiter *et al.,* 2006; Madsen *et al.,* 2006) or in shallow water, where there are advantageous propagation conditions for the higher frequency (but low-energy) components of the airgun signal (Hermannsen *et al.,* 2015). This should not be of concern because the likely behavioral reactions of beaked whales that can result in acute physical injury would result from noise exposure at depth (because of the potentially greater consequences of severe behavioral reactions). In summary, the frequency content of airgun signals is such that beaked whales will not be able to hear the signals well (compared to MFA sonar), especially at depth where we expect the consequences of noise exposure could be more severe.

Aside from frequency content, there are other significant differences between MFA sonar signals and the sounds produced by airguns that minimize the risk of severe behavioral reactions that could lead to strandings or deaths at sea, *e.g.,* significantly longer signal duration, horizontal sound direction, typical fast and unpredictable source movement. All of these characteristics of MFA sonar tend towards greater potential to cause severe behavioral or physiological reactions in exposed beaked whales that may contribute to stranding. Although both sources are powerful, MFA sonar contains significantly greater energy in the mid-frequency range, where beaked whales hear better. Short-duration, high energy pulses—such as those produced by airguns—have greater potential to cause damage to auditory structures (though this is unlikely for mid-frequency cetaceans, as explained later in this document), but it is longer duration signals that have been implicated in the vast majority of beaked whale strandings. Faster, less predictable movements in combination with multiple source vessels are more likely to elicit a severe, potentially anti-predator response. Of additional interest in assessing the divergent characteristics of MFA sonar and airgun signals and their relative potential to cause stranding events or deaths at sea is the similarity between the MFA sonar signals and stereotyped calls of beaked whales' primary predator: The killer whale (Zimmer and Tyack, 2007). Although generic disturbance stimuli—as airgun noise may be considered in this case for beaked whales—may also trigger antipredator responses, stronger responses should generally be expected when perceived risk is greater, as when the stimulus is confused for a known predator (Frid and Dill, 2002). In addition, because the source of the perceived predator (*i.e.,* MFA sonar) will likely be closer to the whales (because attenuation limits the range of detection of mid-frequencies) and moving faster (because it will be on faster-moving vessels), any antipredator response would be more likely to be severe (with greater perceived predation risk, an animal is more likely to disregard the cost of the response; Frid and Dill, 2002). Indeed, when analyzing movements of a beaked whale exposed to playback of killer whale predation calls, Allen *et al.* (2014) found that the whale engaged in a prolonged, directed avoidance response, suggesting a behavioral reaction that could pose a risk factor for stranding. Overall, these significant differences between sound from MFA sonar and the mid-frequency sound component from airguns and the likelihood that MFA sonar signals will be interpreted in error as a predator are critical to understanding the likely risk of behaviorally-mediated injury due to seismic surveys.

The available scientific literature also provides a useful contrast between airgun noise and MFA sonar regarding the likely risk of behaviorally-mediated injury. There is strong evidence for the association of beaked whale stranding events with MFA sonar use, and particularly detailed accounting of several events is available (*e.g.,* a 2000 Bahamas stranding event for which investigators concluded that MFA sonar use was responsible; Evans and England, 2001). D'Amico *et al.* (2009) reviewed 126 beaked whale mass stranding events over the period from 1950 (*i.e.,* from the development of modern MFA sonar systems) through 2004. Of these, there were two events where detailed information was available on both the timing and location of the stranding and the concurrent nearby naval activity, including verification of active MFA sonar usage, with no evidence for an alternative cause of stranding. An additional ten events were at minimum spatially and temporally coincident with naval activity likely to have included MFA sonar use and, despite incomplete knowledge of timing and location of the stranding or the naval activity in some cases, there was no evidence for an alternative cause of stranding. The U.S. Navy has publicly stated agreement that five such events since 1996 were associated in time and space with MFA sonar use, either by the U.S. Navy alone or in joint training exercises with the North Atlantic Treaty Organization. The U.S. Navy additionally noted that, as of 2017, a 2014 beaked whale stranding event in Crete coincident with naval exercises was under review and had not yet been determined to be linked to sonar activities (U.S. Navy, 2017). Separately, the International Council for the Exploration of the Sea reported in 2005 that, worldwide, there have been about 50 known strandings, consisting mostly of beaked whales, with a potential causal link to MFA sonar (ICES, 2005). In contrast, very few such associations have been made to seismic surveys, despite widespread use of airguns as a geophysical sound source in numerous locations around the world.

A more recent review of possible stranding associations with seismic surveys (Castellote and Llorens, 2016) states plainly that, ''[s]peculation concerning possible links between seismic survey noise and cetacean strandings is available for a dozen events but without convincing causal evidence.'' The authors' ''exhaustive'' search of available information found ten events worth further investigation via a ranking system representing a rough metric of the relative level of confidence offered by the data for inferences about the possible role of the seismic survey in a given stranding event. Only three of these events involved beaked whales. Whereas D'Amico *et al.* (2009) used a 1–5 ranking system, in which ''1'' represented the most robust evidence connecting the event to MFA sonar use, Castellote and Llorens (2016) used a 1–6 ranking system, in which ''6'' represented the most robust evidence connecting the event to the seismic survey. As described above, D'Amico *et al.* (2009) found that two events were ranked ''1'' and ten events were ranked ''2'' (*i.e.,* 12 beaked whale stranding events were found to be associated with MFA sonar use). In contrast, Castellote and Llorens (2016) found that none of the three beaked whale stranding events achieved their highest ranks of 5 or 6. Of the ten total events, none achieved the highest rank of 6. Two events were ranked as 5: One stranding in Peru involving dolphins and porpoises and a 2008 stranding in Madagascar. This latter ranking can only broadly be associated with the survey itself, as opposed to use of seismic airguns. An exhaustive investigation of this stranding event, which did not involve beaked whales, concluded that use of a high-frequency mapping system (12-kHz multibeam echosounder) was the most plausible and likely initial behavioral trigger of the event, which was likely exacerbated by several site- and situation-specific secondary factors. The review panel found that seismic airguns were used after the initial strandings and animals entering a lagoon system, that airgun use clearly had no role as an initial trigger, and that there was no evidence that airgun use dissuaded animals from leaving (Southall et al., 2013).

However, one of these stranding events, involving two Cuvier's beaked whales, was contemporaneous with and reasonably associated spatially with a 2002 seismic survey in the Gulf of California conducted by L–DEO, as was the case for the 2007 Gulf of Cadiz seismic survey discussed by Castellote and Llorens (also involving two Cuvier's beaked whales). However, neither event was considered a ''true atypical mass stranding'' (according to Frantzis [1998]) as used in the analysis of Castellote and Llorens (2016). While we agree with the authors that this lack of evidence should not be considered conclusive, it is clear that there is very little evidence that seismic surveys should be considered as posing a significant risk of acute harm to beaked whales or other mid-frequency cetaceans. 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.

Entanglement—Entanglements occur when marine mammals become wrapped around cables, lines, nets, or other objects suspended in the water column. During seismic operations, numerous cables, lines, and other objects primarily associated with the airgun array and hydrophone streamers will be towed behind the *Langseth* near the water‘s surface. However, we are not aware of any cases of entanglement of mysticetes in seismic survey equipment. No incidents of entanglement of marine mammals with seismic survey gear have been documented in over 54,000 nmi (100,000 km) of previous NSF-funded seismic surveys when observers were aboard (*e.g.,* Smultea and Holst 2003; Haley and Koski 2004; Holst 2004; Smultea *et al.,* 2004; Holst *et al.,* 2005a; Haley and Ireland 2006; SIO and NSF 2006b; Hauser *et al.,* 2008; Holst and Smultea 2008). Although entanglement with the streamer is theoretically possible, it has not been documented during tens of thousands of miles of NSF-sponsored seismic cruises or, to our knowledge, during hundreds of thousands of miles of industrial seismic cruises. Entanglement in OBSs and OBNs is also not expected to occur. There are a relative few deployed devices, and no interaction between marine mammals and any such device has been recorded during prior NSF surveys using the devices. There are no meaningful entanglement risks posed by the proposed survey, and entanglement risks are not discussed further in this document.

Anticipated Effects on Marine Mammal Habitat

Physical Disturbance—Sources of seafloor disturbance related to geophysical surveys that may impact marine mammal habitat include placement of anchors, nodes, cables, sensors, or other equipment on or in the seafloor for various activities. Equipment deployed on the seafloor has the potential to cause direct physical damage and could affect bottom-associated fish resources.

Placement of equipment, such as OBSs and OBNs, on the seafloor could damage areas of hard bottom where direct contact with the seafloor occurs and could crush epifauna (organisms that live on the seafloor or surface of other organisms). Damage to unknown or unseen hard bottom could occur, but because of the small area covered by most bottom-founded equipment and the patchy distribution of hard bottom habitat, contact with unknown hard bottom is expected to be rare and impacts minor. Seafloor disturbance in areas of soft bottom can cause loss of small patches of epifauna and infauna due to burial or crushing, and bottom-feeding fishes could be temporarily displaced from feeding areas. Overall, any effects of physical damage to habitat are expected to be minor and temporary.

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, and behavioral responses such as flight or avoidance are the most likely effects. However, the reaction of fish to airguns depends on the physiological state of the fish, past exposures, motivation (*e.g.,* feeding, spawning, migration), and other environmental factors. Several studies have demonstrated that airgun sounds might affect the distribution and behavior of some fishes, potentially impacting foraging opportunities or increasing energetic costs (*e.g.,* Fewtrell and McCauley, 2012; Pearson *et al.,* 1992; Skalski *et al.,* 1992; Santulli *et al.,* 1999; Paxton *et al.,* 2017), though the bulk of studies indicate no or slight reaction to noise (*e.g.,* Miller and Cripps, 2013; Dalen and Knutsen, 1987; Pena *et al.,* 2013; Chapman and Hawkins, 1969; Wardle *et al.,* 2001; Sara *et al.,* 2007; Jorgenson and Gyselman, 2009; Blaxter *et al.,* 1981; Cott *et al.,* 2012; Boeger *et al.,* 2006), and that, most commonly, while there are likely to be impacts to fish as a result of noise from nearby airguns, such effects will be temporary. For example, investigators reported significant, short-term declines in commercial fishing catch rate of gadid fishes during and for up to five days after seismic survey operations, but the catch rate subsequently returned to normal (Engas *et al.,* 1996; Engas and Lokkeborg, 2002). Other studies have reported similar findings (Hassel *et al.,* 2004). Skalski *et al.* (1992) also found a reduction in catch rates—for rockfish (*Sebastes* spp.) in response to controlled airgun exposure—but suggested that the mechanism underlying the decline was not dispersal but rather decreased responsiveness to baited hooks associated with an alarm behavioral response. A companion study showed that alarm and startle responses were not sustained following the removal of the sound source (Pearson *et al.,* 1992). Therefore, Skalski *et al.* (1992) suggested that the effects on fish abundance may be transitory, primarily occurring during the sound exposure itself. In some cases, effects on catch rates are variable within a study, which may be more broadly representative of temporary displacement of fish in response to airgun noise (*i.e.,* catch rates may increase in some locations and decrease in others) than any long-term damage to the fish themselves (Streever *et al.,* 2016).

SPLs of sufficient strength have been known to cause injury to fish and fish mortality and, in some studies, fish auditory systems have been damaged by airgun noise (McCauley *et al.,* 2003; Popper *et al.,* 2005; Song *et al.,* 2008). However, in most fish species, hair cells in the ear continuously regenerate and loss of auditory function likely is restored when damaged cells are replaced with new cells. Halvorsen *et al.* (2012b. (2012) showed that a TTS of 4–6 dB was recoverable within 24 hours for one species. Impacts would be most severe when the individual fish is close to the source and when the duration of exposure is long—both of which are conditions unlikely to occur for this survey that is necessarily transient in any given location and likely result in brief, infrequent noise exposure to prey species in any given area. For this survey, the sound source is constantly moving, and most fish would likely avoid the sound source prior to receiving sound of sufficient intensity to cause physiological or anatomical damage. In addition, ramp-up may allow certain fish species the opportunity to move further away from the sound source.

A recent comprehensive review (Carroll *et al.,* 2017) found that results are mixed as to the effects of airgun noise on the prey of marine mammals. While some studies suggest a change in prey distribution and/or a reduction in prey abundance following the use of seismic airguns, others suggest no effects or even positive effects in prey abundance. As one specific example, Paxton *et al.* (2017), which describes findings related to the effects of a 2014 seismic survey on a reef off of North Carolina, showed a 78 percent decrease in observed nighttime abundance for certain species. It is important to note that the evening hours during which the decline in fish habitat use was recorded (via video recording) occurred on the same day that the seismic survey passed, and no subsequent data is presented to support an inference that the response was long-lasting. Additionally, given that the finding is based on video images, the lack of recorded fish presence does not support a conclusion that the fish actually moved away from the site or suffered any serious impairment. In summary, this particular study corroborates prior studies indicating that a startle response or short-term displacement should be expected.

Available data suggest that cephalopods are capable of sensing the particle motion of sounds and detect low frequencies up to 1–1.5 kHz, depending on the species, and so are likely to detect airgun noise (Kaifu *et al.,* 2008; Hu *et al.,* 2009; Mooney *et al.,* 2010; Samson *et al.,* 2014). Auditory injuries (lesions occurring on the statocyst sensory hair cells) have been reported upon controlled exposure to low-frequency sounds, suggesting that cephalopods are particularly sensitive to low-frequency sound (Andre *et al.,* 2011; Sole *et al.,* 2013). Behavioral responses, such as inking and jetting, have also been reported upon exposure to low-frequency sound (McCauley *et al.,* 2000b; Samson *et al.,* 2014). Similar to fish, however, the transient nature of the survey leads to an expectation that effects will be largely limited to behavioral reactions and would occur as a result of brief, infrequent exposures.

With regard to potential impacts on zooplankton, McCauley *et al.* (2017) found that exposure to airgun noise resulted in significant depletion for more than half the taxa present and that there were two to three times more dead zooplankton after airgun exposure compared with controls for all taxa, within 1 km of the airguns. However, the authors also stated that in order to have significant impacts on r-selected species (*i.e.,* those with high growth rates and that produce many offspring) such as plankton, the spatial or temporal scale of impact must be large in comparison with the ecosystem concerned, and it is possible that the findings reflect avoidance by zooplankton rather than mortality (McCauley *et al.,* 2017). In addition, the results of this study are inconsistent with a large body of research that generally finds limited spatial and temporal impacts to zooplankton as a result of exposure to airgun noise (*e.g.,* Dalen and Knutsen, 1987; Payne, 2004; Stanley *et al.,* 2011). Most prior research on this topic, which has focused on relatively small spatial scales, has showed minimal effects (*e.g.,* Kostyuchenko, 1973; Booman *et al.,* 1996; Sætre and Ona, 1996; Pearson *et al.,* 1994; Bolle *et al.,* 2012).

A modeling exercise was conducted as a follow-up to the McCauley *et al.* (2017) study (as recommended by McCauley *et al.*), in order to assess the potential for impacts on ocean ecosystem dynamics and zooplankton population dynamics (Richardson *et al.,* 2017). Richardson *et al.* (2017) found that for copepods with a short life cycle in a high-energy environment, a full-scale airgun survey would impact copepod abundance up to three days following the end of the survey, suggesting that effects such as those found by McCauley *et al.* (2017) would not be expected to be detectable downstream of the survey areas, either spatially or temporally.

Notably, a recently described study produced results inconsistent with those of McCauley *et al.* (2017). Researchers conducted a field and laboratory study to assess if exposure to airgun noise affects mortality, predator escape response, or gene expression of the copepod *Calanus finmarchicus* (Fields *et al.,* 2019). Immediate mortality of copepods was significantly higher, relative to controls, at distances of 5 m or less from the airguns. Mortality one week after the airgun blast was significantly higher in the copepods placed 10 m from the airgun but was not significantly different from the controls at a distance of 20 m from the airgun. The increase in mortality, relative to controls, did not exceed 30 percent at any distance from the airgun. Moreover, the authors caution that even this higher mortality in the immediate vicinity of the airguns may be more pronounced than what would be observed in free-swimming animals due to increased flow speed of fluid inside bags containing the experimental animals. There were no sublethal effects on the escape performance or the sensory threshold needed to initiate an escape response at any of the distances from the airgun that were tested. Whereas McCauley *et al.* (2017) reported an SEL of 156 dB at a range of 509–658 m, with zooplankton mortality observed at that range, Fields *et al.* (2019) reported an SEL of 186 dB at a range of 25 m, with no reported mortality at that distance. Regardless, if we assume a worst-case likelihood of severe impacts to zooplankton within approximately 1 km of the acoustic source, the brief time to regeneration of the potentially affected zooplankton populations does not lead us to expect any meaningful follow-on effects to the prey base for marine mammals.

A recent review article concluded that, while laboratory results provide scientific evidence for high-intensity and low-frequency sound-induced physical trauma and other negative effects on some fish and invertebrates, the sound exposure scenarios in some cases are not realistic to those encountered by marine organisms during routine seismic operations (Carroll *et al.,* 2017). The review finds that there has been no evidence of reduced catch or abundance following seismic activities for invertebrates, and that there is conflicting evidence for fish with catch observed to increase, decrease, or remain the same. Further, where there is evidence for decreased catch rates in response to airgun noise, these findings provide no information about the underlying biological cause of catch rate reduction (Carroll *et al.,* 2017).

In summary, impacts of the specified activity on marine mammal prey species will likely be limited to behavioral responses, the majority of prey species will be capable of moving out of the area during the survey, a rapid return to normal recruitment, distribution, and behavior for prey species is anticipated, and, overall, impacts to prey species will be minor and temporary. Prey species exposed to sound might move away from the sound source, experience TTS, experience masking of biologically relevant sounds, or show no obvious direct effects. Mortality from decompression injuries is possible in close proximity to a sound, but only limited data on mortality in response to airgun noise exposure are available (Hawkins *et al.,* 2014). The most likely impacts for most prey species in the survey area would be temporary avoidance of the area. The proposed survey would move through an area relatively quickly, limiting exposure to multiple impulsive sounds. In all cases, sound levels would return to ambient once the survey moves out of the area or ends and the noise source is shut down and, when exposure to sound ends, behavioral and/or physiological responses are expected to end relatively quickly (McCauley *et al.,* 2000b). 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. While the potential for disruption of spawning aggregations or schools of important prey species can be meaningful on a local scale, the mobile and temporary nature of this survey and the likelihood of temporary avoidance behavior suggest that impacts would be minor.

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 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.

Based on the information discussed herein, we conclude that impacts of the specified activity are not likely to have more than short-term adverse effects on any prey habitat or populations of prey species. Further, any impacts to marine mammal habitat are not expected to result in significant or long-term consequences for individual marine mammals, or to contribute to adverse impacts on 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.,* porpoises, *Kogia* spp.). The proposed mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable.

As described previously, no serious injury or 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

NMFS uses 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). 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

Hearing Group	PTS onset acoustic thresholds* (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 $1 \mu Pa^2 s$. 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 acoustic propagation modeling.

L–DEO's modeling methodology is described in greater detail in the IHA application (LGL 2019). The proposed 2D survey would acquire data using the 36-airgun array with a total discharge volume of 6,600 in^3 at a maximum tow depth of 12 m. L–DEO model results are used to determine the 160-dBrms radius for the 36-airgun array in deep water (>1,000 m) down to a maximum water depth of 2,000 m. Water depths in the project area may be up to 4,400 m, but marine mammals are generally not anticipated to dive below 2,000 m (Costa and Williams 1999). 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 harassment 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 2,000 m.

A recent retrospective analysis of acoustic propagation from use of the *Langseth* sources during a 2012 survey off Washington (*i.e.,* in the same location) suggests that predicted (modeled) radii (using the same approach as that used here) were 2–3 times larger than the measured radii in shallow water. (Crone *et al.,* 2014). Therefore, because the modeled shallow-water radii were specifically demonstrated to be overly conservative for the region in which the current survey is planned, L–DEO used the received levels from multichannel seismic data collected by the *Langseth* during the 2012 survey to estimate Level B harassment radii in shallow (<100 m) and intermediate (100–1,000 m) depths (Crone *et al.,* 2014). Streamer data in shallow water collected in 2012 have the advantage of including the effects of local and complex subsurface geology, seafloor topography, and water column properties, and thus allow determination of radii more confidently than using data from calibration experiments in the Gulf of Mexico.

The proposed survey would acquire data with a four-string 6,600-in^3 airgun array at a tow depth of 12 m while the data collected in 2012 were acquired with the same airgun array at a tow depth of 9 m. To account for the differences in tow depth between the 2012 survey and the proposed 2020 survey, L–DEO calculated a scaling factor using the deep water modeling (see Appendix D in L–DEO's IHA application). A scaling factor of 1.15 was applied to the measured radii from the airgun array towed at 9 m.

The estimated distances to the Level B harassment isopleth for the *Langseth's* 36-airgun array are shown in Table 4.

TABLE 4—PREDICTED RADIAL DISTANCES TO ISOPLETHS CORRESPONDING TO LEVEL B HARASSMENT THRESHOLD

Source and volume	Tow depth (m)	Water depth (m)	Level B harassment zone (m) using L–DEO model
36 airgun array, 6,600-in^3	12	>1000 100–1000 <100	[a] 6,733 [b] 9,468 [b] 12,650

[a] Distance based on L–DEO model results.

[b] Distance based on data from Crone *et al.* (2014).

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 source modeling software program and the NMFS User Spreadsheet, described below. The 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 2018). 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 6,600-IN^3 AIRGUN ARRAY

	Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $_{LE,MF,24h}$: 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)
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	232.84	233.10	232.84	232.08

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 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 (4.2 knots) and shot intervals (37.5 m) specific to the planned survey, potential radial distances to auditory injury zones were then calculated for $\mathrm{SEL_{cum}}$ 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 36-airgun array for the surveys are shown in Table A–3 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 survey 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 ($\mathrm{SEL_{cum}}$ and Peak $\mathrm{SPL_{flat}}$) 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 (volume)	Threshold	Level A harassment zone (m)				
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids	Otariids
36-airgun array (6,600 in^3).	$\mathrm{SEL_{cum}}$	426.9	0	1.3	13.9	0
	Peak	38.9	13.6	268.3	43.7	10.6

Note that because of some of the assumptions included in the methods used (*e.g.,* stationary receiver with no vertical or horizontal movement in response to the acoustic source), isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimation 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.

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), in context of distributed source dynamics. 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 $D >> \lambda$, and where D is the distance, L is the longest dimension of the 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 5 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 *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 5 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 proposed 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). Given this, relying on the calculated distance (138.7 m) as the distance 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.

In consideration of the received sound levels in the near-field as described above, 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.

Marine Mammal Occurrence

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

Extensive systematic aircraft- and ship-based surveys have been conducted for marine mammals in offshore waters of Oregon and Washington (*e.g.,* Bonnell *et al.,* 1992; Green *et al.,* 1992, 1993; Barlow 1997, 2003; Barlow and Taylor 2001; Calambokidis and Barlow 2004; Barlow and Forney 2007; Forney 2007; Barlow 2010). Ship surveys for cetaceans in slope and offshore waters of Oregon and Washington were conducted by NMFS' Southwest Fisheries Science Center (SWFSC) in 1991, 1993, 1996, 2001, 2005, 2008, and 2014 and synthesized by Barlow (2016); these surveys were conducted from the coastline up to ~556 km from shore from June or August to November or December. These data were used by the SWFSC to develop spatial models of cetacean densities for the California Current Ecosystem (CCE). Systematic, offshore, at-sea survey data for pinnipeds are more limited (*e.g.,* Bonnell *et al.,* 1992; Adams *et al.,* 2014); In British Columbia, several systematic surveys have been conducted in coastal waters (*e.g.,* Williams and Thomas 2007; Ford *et al.,* 2010a; Best *et al.,* 2015; Harvey *et al.,* 2017). Surveys in coastal as well as offshore waters were conducted by DFO during 2002 to 2008; however, little effort occurred off the west coast of Vancouver Island during late spring/summer (Ford *et al.,* 2010). Density estimates for the proposed survey areas outside the U.S. EEZ, *i.e.,* in the Canadian EEZ, were not readily available, so density estimates for U.S. waters were applied to the entire survey area.

The U.S. Navy primarily used SWFSC habitat-based cetacean density models to develop a marine species density database (MSDD) for the Northwest Training and Testing (NWTT) Study Area for NWTT Phase III activities (U.S. Navy 2019a), which encompasses the U.S. portion of the proposed survey 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 spatially- or temporally-explicit density information. 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 (spatially and temporally) 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. In addition to using shore counts to estimate pinniped density, traditional line-transect derived estimates are also used, particularly in open ocean areas.

The Navy's MSDD is currently the most comprehensive compendium for density data available for the CCE. However, data products are currently not publically available for the database; thus, in this analysis the Navy's data products were used only for species for which density data were not available from an alternative spatially-explicit model (*e.g.,* pinnipeds, *Kogia* spp., minke whales, sei whales, gray whales, short-finned pilot whales, and Northern Resident, transient, and offshore killer whales). For these species, GIS was used to determine the areas expected to be ensonified in each density category (*i.e.,* distance from shore). For pinnipeds, the densities from the Navy's MSDD were corrected by projecting the most recent population growth and updated population estimates to 2020, when available. Where available, the appropriate seasonal density estimate from the MSDD was used in the estimation here (*i.e.,* summer).

NMFS obtained data products from the Navy for densities of Southern Resident killer whales in the NWTT Offshore Study Area. The modeled density estimates were available on the scale of 1 km by 1 km grid cells. The densities from grid cells overlapping the ensonified area in each depth category were multiplied by the corresponding area to estimate potential exposures (Table 9).

For most other species, (*i.e.,* humpback, blue, fin, sperm, Baird's beaked, and other small beaked whales; bottlenose, striped, common, Pacific white-sided, Risso's and northern right whale dolphins; and Dall's porpoise), habitat-based density models from Becker *et al.* (2016) were used. Becker *et al.* (2016) used seven years of SWFSC cetacean line-transect survey data collected between 1991 and 2009 to develop predictive habitat-based models of cetacean densities in the CCE. The modeled density estimates were available on the scale of 7 km by 10 km grid cells. The densities from all grid cells overlapping the ensonified areas within each water depth category were averaged to calculate a zone-specific density for each species.

Becker *et al.* (2016) did not develop a density model for the harbor porpoise, so densities from Forney *et al.* (2014) were used for that species. Forney *et al.* (2014) presented estimates of harbor porpoise abundance and density along the Pacific coast of California, Oregon, and Washington based on aerial line-transect surveys conducted between 2007 and 2012. Separate density estimates were provided for harbor porpoises in Oregon south of 45° N and Oregon/Washington north of 45° N (*i.e.,* within the boundaries of the Northern California/Southern Oregon and Northern Oregon/Washington Coast stocks), so stock-specific take estimates were generated (Forney *et al.,* 2014).

Background information on the density calculations for each species/guild (if different from the general methods from the Navy's MSDD, Becker *et al.* (2016), or Forney *et al.* (2014) described above) are reported here. Density estimates for each species/guild (aside from Southern Resident killer whales, which are discussed separately) are found in Table 7.

Gray Whale

DeAngelis *et al.* (2011) developed a migration model that provides monthly, spatially explicit predictions of gray whale abundance along the U.S. West Coast from December through June. These monthly density estimates apply to a ''main migration corridor'' that extends from the coast to 10 km offshore. A zone from the main migration corridor out to 47 km offshore is designated as an area of ''potential presence''. To derive a density estimate for this area the Navy assumed that 1 percent of the population could be within the 47-km ''potential presence'' area during migration. Given the 2014 stock assessment population estimate of 20,990 animals (Carretta *et al.,* 2017b), approximately 210 gray whales may use this corridor. Assuming the migration wave lasts 30 days, then 7 whales on average on any one day could occur in the ''potential presence'' area. The area from the main migration route offshore to 47 km within the NWTT study area = 45,722.06 km^2, so density within this zone = 0.00015 whales/km^2. From July–November, gray whale occurrence off the coast is expected to consist primarily of whales belonging to the PCFG. Calambokidis *et al.* (2012) provided an updated analysis of the abundance of the PCFG whales in the Pacific Northwest and recognized that this group forms a distinct feeding aggregation. For the purposes of establishing density, the Navy assumed that from July 1 to November 30 all the 209 PCFG whales could be present off the coast in the Northern California/Oregon/Washington region (this accounts for the potential that some PCFG whales may be outside of the area but that there also may be some non-PCFG whales in the region as noted by Calambokidis *et al.*(2012)). Given that the PCFG whales are found largely nearshore, it was assumed that all the whales could be within 10 km of the coast. To capture the potential presence of whales further offshore (*e.g.,* Oleson *et al.,* 2009), it was assumed that a percentage of the whales could be present from 10 km out to 47 km off the coast; the 47 km outer limit is consistent with the DeAngelis *et al.* (2011) migration model. Since 77 percent of the PCFG sightings were within the nearshore BIAs (Calambokidis *et al.,* 2015), it was assumed that 23 percent (48 whales) could potentially be found further offshore. Two strata were thus developed for the July–November gray whale density layers: (1) From the coast to 10 km offshore, and (2) from 10 km to 47 km offshore. The density was assumed to be 0 animals/km^2 for areas offshore of 47 km.

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 2009 (Becker *et al.,* 2016).

False Killer Whale

False killer whales were not included in the Navy's MSDD, as they are very rarely encountered in the northeast Pacific. Density estimates for false killer whales were also not presented in Barlow (2016) or Becker *et al.* (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). One pod of false killer whales occurred in Puget Sound for several months during the 1990s (Navy 2015). Based on the available information, NMFS does not believe false killer whales are expected to be taken, but L–DEO has requested take of this species so we are proposing to authorize take.

Killer Whale

A combination of movement data (from both visual observations and satellite-linked tags) and detections from stationary acoustic recorders have provided information on the offshore distribution of the Southern Resident stock (Hanson *et al.,* 2018). These data have been used to develop state space movement models that provide estimates of the probability of occurrence (or relative density) of Southern Residents in the offshore study area in winter and spring (Hanson *et al.,* 2018). Since the total number of animals that comprise each pod is known, the relative density estimates were used in association with the total abundance estimates to derive absolute density estimates (*i.e.,* number of animals/km^2) within the offshore study area. Given that the K and L pods were together during all but one of the satellite tag deployments, Hanson *et al.* (2018) developed two separate state space models, one for the combined K and L pods and one for the J pod. The absolute density estimates were thus derived based on a total of 53 animals for the K and L pods (K pod = 18 animals, L pod = 35 animals) and 22 animals for the J pod (Center for Whale Research, 2019). Of the three pods, the

K and L pods appear to have a more extensive and seasonally variable offshore coastal distribution, with rare sightings as far south as Monterey Bay, California (Carretta *et al.,* 2019; Ford *et al.,* 2000; Hanson *et al.,* 2018). Two seasonal density maps were thus developed for the K and L pods, one representing their distribution from January to May (the duration of the tag deployments), and another representing their distribution from June to December. Based on stationary acoustic recording data, their excursions offshore from June to December are more limited and typically do not extend south of the Columbia River (Emmons 2019). To provide more conservative density estimates, the Navy extended the June to December distribution to just south of the Columbia River and redistributed the total K and L populations (53 animals) within the more limited range boundaries. A conservative approach was also adopted for the J pod since the January to May density estimates were assumed to represent annual occurrence patterns, despite information that this pod typically spends more time in the inland waters during the summer and fall (Carretta *et al.,* 2019; Ford *et al.,* 2000; Hanson *et al.,* 2018). Further, for all seasons the Navy assumed that all members of the three pods of Southern Residents could occur either offshore or in the inland waters, so the total number of animals in the stock was used to derive density estimates for both study areas.

Due to the difficulties associated with reliably distinguishing the different stocks of killer whales from at sea sightings, and anticipated equal likelihood of occurrence among the stocks, density estimates for the rest of the stocks are presented as a whole (*i.e.,* includes the Offshore, West Coast Transient, and Northern Resident stocks). Barlow (2016) presents density values for killer whales in the CCE, with separate densities for waters off Oregon/Washington (*i.e.,* north of the California border) and Northern California for summer/fall. Density data are not available for the NWTT Offshore area northwest of the CCE study area, so data from the SWFSC Oregon/Washington area were used as representative estimates. These values were used to represent density year-round.

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.

Guadalupe Fur Seal

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 planned 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 Guadalupe 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 planned 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.

The Navy's density estimate for Guadalupe fur seals projected the abundance through 2017, while L–DEO's survey will occur in 2020. Therefore, we have projected the abundance estimate in 2020 using the abundance estimate (34,187 animals) and population growth rate (5.9 percent) presented in the 2019 draft SARs (Caretta *et al.,* 2019). This calculation yielded an increased density estimate of Guadalupe fur seals than what was presented in the Navy's MSDD.

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 planned survey area during the planned 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 planned 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.

The Navy's density estimates for northern fur seals did not include the latest abundance data collected from Bogoslof Island or the Pribilof Islands in 2015 and 2016. Incorporating the latest pup counts yielded a slight decrease in the population abundance estimate, which resulted in a slight decrease in the estimated densities of northern fur seals in each depth stratum.

Steller Sea Lion

The Eastern stock of Steller sea lions has established rookeries and breeding sites along the coasts of California, Oregon, British Columbia, and southeast Alaska. A new rookery was recently discovered along the coast of Washington at the Carroll Island and Sea Lion Rock complete, where more than 100 pups were born in 2015 (Muto *et al.,* 2017; Wiles 2015). The 2017 SAR did not factor in pups born at sites along the Washington coast (Muto *et al.,* 2017). Considering that pups have been observed at multiple breeding sites since 2013, specifically at the Carroll Island and Sea Lion Rock complex (Wiles 2015), the 2017 SAR abundance of 1,407 Steller sea lions (non-pups only) for Washington underestimates the total population. Wiles (2015) estimates that up to 2,500 Steller sea lions are present along the Washington coast, which is the abundance estimate used by the Navy to calculate densities. Approximately 30,000 Steller sea lions occur along the coast of British Columbia, but these animals were not included in the Navy's calculations. The Navy applied the annual growth rate for each regional population (California, Oregon, Washington, and southeast Alaska), reported in Muto *et al.* (2017), to each population to estimate the stock abundance in 2017, and we further projected the population estimate in 2020.

Sea lions from northern California and southern Oregon rookeries migrate north in September following the breeding season and winter in northern Oregon, Washington, and British Columbia waters. They disperse widely following the breeding season, which extends from May through July, likely in search of different types of prey, which may be concentrated in areas where oceanic fronts and eddies persist (Fritz *et al.,* 2016; Jemison *et al.,* 2013; Lander *et al.,* 2010; Muto *et al.,* 2017; NMFS 2013; Raum-Suryan *et al.,* 2004; Sigler *et al.,* 2017). Adults depart rookeries in August. Females with pups remain within 500 km of their rookery during the non-breeding season and juveniles of both sexes and adult males disperse more widely but remain primarily over the continental shelf (Wiles 2015).

Based on 11 sightings along the Washington coast, Steller sea lions were observed at an average distance of 13 km from shore and 35 km from the shelf break (defined as the 200-m isobath) (Oleson *et al.,* 2009). The mean water depth in the area of occurrence was 42 m, and surveys were conducted out to approximately 60 km from shore. Wiles (2015) estimated that Steller sea lions off the Washington coast primarily occurred within 60 km of shore, favoring habitats over the continental shelf. However, a few individuals may travel several hundred km offshore (Merrick & Loughlin 1997; Wiles 2015). Based on these occurrence and distribution data, two strata were used to estimate densities for Steller sea lions. The spatial area extending from shore to the 200-m isobath (*i.e.,* over the continental shelf) was defined as one stratum, and the second stratum extended from the 200-m isobath to 300 km from shore to account for reports of Steller sea lions occurring several hundred km offshore. Ninety-five percent of the population of Steller sea lions occurring in the NWTT Study Area were distributed over the continental shelf stratum and the remaining five percent were assumed to occur between the 200-m isobath and 300 km from shore.

The percentage of time Steller sea lions spend hauled out varies by season, life stage, and geographic location. To calculated densities in the Study Area, the projected population abundance was adjusted to account for time spent hauled out. In spring and winter, sea lions were estimated to be in the water 64 percent of the time. In summer, when sea lions are more likely to be in the water, the percent of animals estimated to be in the water was increased to 76 percent, and in fall, sea lions were anticipated to be in the water 53 percent of the time (U.S. Navy 2019). Densities were calculated for each depth stratum off Washington and off Oregon.

California Sea Lion

Seasonal at-sea abundance of California sea lions is estimated from strip transect survey data collected offshore along the California coastline (Lowry & Forney 2005). The survey area was divided into seven strata, labeled A through G. Abundance estimates from the two northernmost strata (A and B) were used to estimate the abundance of California sea lions occurring in the NWTT Study Area. While the northernmost stratum (A) only partially overlaps with the Study Area, this approach conservatively assumes that all sea lions from the two strata would continue north into the Study Area.

The majority of male sea lions would be expected in the NWTT Study Area from August to mid-June (Wright *et al.,* 2010). In summer, males are expected to be at breeding sites off of Southern California. In-water abundance estimates of adult and sub-adult males in strata A and B were extrapolated to estimate seasonal densities in the Study Area. Approximately 3,000 male California sea lions are known to pass through the NWTT Study Area in August as they migrate northward to the Washington coast and inland waters (DeLong 2018a; Wright *et al.,* 2010). Nearly all male sea lions are expected to be on or near breeding sites off California in July (DeLong *et al.,* 2017; Wright *et al.,* 2010). An estimate of 3,000 male sea lions is used for the month of August. Projected 2017 seasonal abundance estimates were derived by applying an annual growth rate of 5.4 percent (Caretta *et al.,* 2017b) between 1999 and 2017 to the abundance estimates from Lowry & Forney (2005).

The strata used to calculated densities in the NWTT Study Area were based on distribution data from Wright *et al.* (2010) and Lowry & Forney (2005) indicating that approximately 90 percent of California sea lions occurred within 40 km of shore and 100 percent of sea lions were within 70 km of shore. A third stratum was added that extends from shore to 450 km offshore to account for anomalous conditions, such as changes in sea surface temperature and upwelling associated with El Niño, during which California sea lions have been encountered farther from shore, presumably seeking prey (DeLong & Jeffries 2017; Weise *et al.,* 2010). The Navy calculated densities for each stratum (0 to 40 km, 40 to 70 km, and 0 to 450 km) for each season, spring, summer, fall, and winter, but noted that the density of California sea lions in all strata for June and July was 0 animals/km^2. The Navy's calculated densities for August were conservatively used here, as sightings of California sea lions have been reported on the continental shelf in June and July (Adams *et al.,* 2014).

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.

As with other pinniped species above, NMFS used the population growth rate reported by Caretta *et al.* (2017b) to project the estimated abundance in 2020. The resulting population estimate and estimated densities increased from those presented in the Navy's MSDD (U.S. Navy 2019).

Harbor Seal

Only harbor seals from the Washington and Oregon Coast stock would be expected to occur in the proposed survey area. The most recent abundance estimate for the Washington and Oregon Coast stock is 24,732 harbor seals (Caretta *et al.,* 2017b). Survey data supporting this abundance estimate are from 1999, which exceeds the eight-year limit beyond which NMFS will not confirm abundance in a SAR (Caretta *et al.,* 2017b). However, based on logistical growth curves for the Washington and Oregon Coast stock that leveled off in the early 1990s (Caretta *et al.,* 2017b) and unpublished data from the Washington Department of Fish and Wildlife (DeLong & Jeffries 2017), an annual growth rate of 0 percent (*i.e.,* the population has remained stable) was applied such that the 2017 abundance estimate used by the Navy, and 2020 estimate used here, was still 24,732 harbor seals. A haulout factor of 33 percent was used to account for hauled-out seals (*i.e.,* seals are estimated to be in the water 33 percent of the time) (Huber *et al.,* 2001). A single stratum extending from shore to 30 km offshore was used to define the spatial area used by the Navy for calculating densities off Washington and Oregon (Bailey *et al.,* 2014; Oleson *et al.,* 2009).

Marine Mammal Densities

Densities for most species are presented by depth stratum (shallow, intermediate, and deep water) in Table 7. For species where densities are available based on other categories (gray whale, harbor porpoise, northern fur seal, Guadalupe fur seal, California sea lion, Steller sea lion), category definitions are provided in the footnotes of Table 7.

TABLE 7—MARINE MAMMAL DENSITY VALUES IN THE SURVEY AREA

Species	Estimated density (#/km²)			Reference
	Shallow <100 m/category 1	Intermediate 100–1000 m/category 2	Deep >1000 m/category 3	
LF Cetaceans:				
Humpback whale	0.0052405	0.0040200	0.0004830	Becker *et al.* (2016).
Blue whale	0.0020235	0.0010518	0.0003576	Becker *et al.* (2016).
Fin whale	0.0002016	0.0009306	0.0013810	Becker *et al.* (2016).
Sei whale	0.0004000	0.0004000	0.0004000	U.S. Navy (2019).
Minke whale	0.0013000	0.0013000	0.0013000	U.S. Navy (2019).
Gray whale [a]	0.0155000	0.0010000	N.A.	U.S. Navy (2019).
MF Cetaceans:				
Sperm whale	0.0000586	0.0001560	0.0013023	Becker *et al.* (2016).
Baird's beaked whale	0.0001142	0.0002998	0.0014680	Becker *et al.* (2016).
Small beaked whale	0.0007878	0.0013562	0.0039516	Becker *et al.* (2016).
Bottlenose dolphin	0.0000007	0.0000011	0.0000108	Becker *et al.* (2016).
Striped dolphin	0.0000000	0.0000025	0.0001332	Becker *et al.* (2016).
Short-beaked common dolphin	0.0005075	0.0010287	0.0016437	Becker *et al.* (2016).
Pacific white-sided dolphin	0.0515230	0.0948355	0.0700595	Becker *et al.* (2016).
Northern right-whale dolphin	0.0101779	0.0435350	0.0621242	Becker *et al.* (2016).
Risso's dolphin	0.0306137	0.0308426	0.0158850	Becker *et al.* (2016).
False killer whale [b]	N.A.	N.A.	N.A.	
Killer whale (all stocks except Southern Residents).	0.0009200	0.0009200	0.0009200	U.S. Navy (2019).
Short-finned pilot whale	0.0002500	0.0002500	0.0002500	U.S. Navy (2019).
HF Cetaceans:				
Pygmy/dwarf sperm whale	0.0016300	0.0016300	0.0016300	U.S. Navy (2019).
Dall's porpoise	0.1450767	0.1610605	0.1131827	Becker *et al.* (2016).
Harbor porpoise [c]	0.6240000	0.4670000	N.A.	Forney *et al.* (2014).
Otariids:				
Northern fur seal [d]	0.0113247	0.1346441	0.0103424	U.S. Navy (2019).
Guadalupe fur seal [e]	0.0234772	0.0262595	N.A.	U.S. Navy (2019).
California sea lion [f]	0.0288000	0.0037000	0.0065000	U.S. Navy (2019).
Steller sea lion [g]	0.3088864	0.0022224	N.A.	U.S. Navy (2019).
Phocids:				
Northern elephant seal	0.0345997	0.0345997	0.0345997	U.S. Navy (2019).
Harbor seal [h]	0.3424000	N.A.	N.A.	U.S. Navy (2019).

[a] Category 1 = 0–10 km offshore, Category 2 = 10–47 km offshore (U.S. Navy 2019).

[b] No density estimates available for false killer whales in the survey area, take is based on mean group size from Mobley *et al.* (2000).

[c] Category 1 = South of 45° N, Category 2 = North of 45° N (Forney *et al.,* 2014).

[d] Category 1 = 22–70 km offshore, Category 2 = 70–130 km offshore, Category 3 = 130–463 km offshore (U.S. Navy 2019).

[e] Category 1 = 10–200 m depth, Category 2 = 200 m depth–300 km offshore; No stock-specific densities are available so these densities were applied to northern fur seals as a species (U.S. Navy 2019).

[f] Category 1 = 0–40 km offshore, Category 2 = 40–70 km offshore, Category 3 = 0–450 km offshore (U.S. Navy 2019).

[g] Category 1 = shore–200 m depth, Category 2 = 200 m depth–300 m offshore (U.S. Navy 2019).

[h] Category 1 = 0–30 km offshore (U.S. Navy 2019).

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 distance for the 160-dB threshold (based on L–DEO model results) was used to draw a buffer around every transect line in GIS to determine the total ensonified area in each depth category (Table 8). The areas presented in Table 8 do not include areas ensonified within Canadian territorial waters (from 0–12 nmi (22.2 km) from shore). As discussed above, NMFS cannot authorize the incidental take of marine mammals in the territorial seas of foreign nations, as the MMPA does not apply in those waters. However, NMFS has still calculated the level of incidental take in the entire activity area (including Canadian territorial waters) as part of the analysis supporting our preliminary determination under the MMPA that the activity will have a negligible impact on the affected species. The total estimated take in U.S. and Canadian waters is presented in Table 11.

In past applications, to account for unanticipated delays in operations, L–DEO has added 25 percent in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed. In this application, however, due to the strict operational timelines and availability of the R/V *Langseth,* no additional time or distance has been added to the survey calculations. 37 days is the absolute maximum amount of time the R/V *Langseth* is available to conduct seismic operations.

The ensonified areas in Table 8 were used to estimate take of marine mammal species with densities available for the three depth strata (shallow, intermediate, and deep waters). For other species where densities are available based on other categories (*i.e.,* gray whale, harbor porpoise, northern fur seal, Guadalupe fur seal, California sea lion, Steller sea lion; see Table 7), GIS was used to determine the areas expected to be ensonified in each density category (see Table B–2 in L–DEO's application for the ensonified areas in each category).

TABLE 8—AREAS (KM^2) ESTIMATED TO BE ENSONIFIED TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS

Survey zone	Criteria	Relevant isopleth (m)	Total ensonified area (km^2)
Level B Harassment:			
Shallow <100 m	160 dB	[a] 12,650	11,433.80
Intermediate 100–1000 m	160 dB	[b] 9,468	24,200.75
Deep >1000 m	160 dB	[b] 6,733	50,924.56
		Overall	86,559.11
Level A Harassment			
All depth zones	LF Cetacean	426.9	5,605.34
	MF Cetacean	13.6	179.85
	HF Cetacean	268.3	3,532.92
	Otariid	10.6	140.19
	Phocid	43.7	577.63

[a] Based on L–DEO model results.

[b] Based on data from Crone *et al.* (2014).

Density estimates for Southern Resident killer whales from the U.S. Navy's MSDD were overlaid with GIS layers of the Level B harassment zones in each depth category to determine the areas expected to be ensonified in each density category (Table 9).

TABLE 9—SOUTHERN RESIDENT KILLER WHALE DENSITIES AND CORRESPONDING ENSONIFIED AREAS

Pod	Density (animals/km^2)	Ensonified area (km^2)
K/L	0.000000	5,883
	0.000001—0.002803	17,875
	0.002804—0.005615	2,817
	0.005616—0.009366	1,200
	0.009367—0.015185	320
J	0.000000	7,260
	0.000001—0.001991	8,648
	0.001992—0.005010	1,128

TABLE 9—SOUTHERN RESIDENT KILLER WHALE DENSITIES AND CORRESPONDING ENSONIFIED AREAS—Continued

Pod	Density (animals/km^2)	Ensonified area (km^2)
	0.005011—0.009602	236
	0.009603—0.018822	20

The marine mammals predicted to occur within these respective areas, based on estimated densities or other occurrence records, are assumed to be incidentally taken. For species where NMFS expects take by Level A harassment to potentially occur, the calculated Level A harassment takes have been subtracted from the total within the Level B harassment zone. Estimated exposures for the proposed survey outside of Canadian territorial waters are shown in Table 10.

TABLE 10—ESTIMATED TAKING BY LEVEL A AND LEVEL B HARASSMENT, AND PERCENTAGE OF POPULATION

Species	MMPA stock[a]	Stock abundance	Estimated take		Total proposed take	Percent of MMPA stock
			Level B	Level A		
LF Cetaceans:						
Humpback whale	Central North Pacific	10,103	172	10	[b]182	1.80
	California/Oregon/Washington.	2,900				6.28
Blue whale	Eastern North Pacific	1,647	63	4	67	4.06
Fin whale	California/Oregon/Washington.	9,029	89	6	95	1.06
	Northeast Pacific	3,168				3.01
Sei whale	Eastern North Pacific	27,197	32	2	34	0.13
Minke whale	California/Oregon/Washington.	25,000	105	7	112	0.45
Gray whale	Eastern North Pacific	26,960	90	2	92	0.34
MF Cetaceans:						
Sperm whale	California/Oregon/Washington.	26,300	71	0	71	0.27
Baird's beaked whale	California/Oregon/Washington.	2,697	83	0	83	3.08
Small beaked whale	California/Oregon/Washington.	6,318	244	0	[c]244	3.86
Bottlenose dolphin	California/Oregon/Washington (offshore).	1,924	1	0	[d]13	0.68
Striped dolphin	California/Oregon/Washington.	29,211	7	0	[d]46	0.16
Short-beaked common dolphin.	California/Oregon/Washington.	969,861	114	0	[d]179	0.02
Pacific white-sided dolphin.	California/Oregon/Washington.	26,814	6,452	0	6,452	24.06
Northern right-whale dolphin.	California/Oregon/Washington.	26,556	4,333	0	4,333	16.32
Risso's dolphin	California/Oregon/Washington.	6,336	1,906	0	1,906	30.08
False killer whale	N.A.	N.A.	N.A.	N.A.	[e]5	N.A.
Killer whale	Southern Resident	75	43	0	43	[g]57.33
	Northern Resident	302	27	0	[f]27	8.94
	West Coast Transient	243	26		[f]26	10.70
	Offshore	300	26		[f]26	8.67
Short-finned pilot whale	California/Oregon/Washington.	836	24	0	[d]29	3.47
HF Cetaceans:						
Pygmy/dwarf sperm whale.	California/Oregon/Washington.	4,111	135	6	141	3.42
Dall's porpoise	California/Oregon/Washington.	27,750	10,869	452	11,321	[g]40.80
Harbor porpoise	Northern Oregon/Washington Coast.	21,487	12,557	449	13,006	[g]60.53
	Northern California/Southern Oregon.	35,769				[g]36.36
Otariid Seals:						
Northern fur seal	Eastern Pacific	620,660	4,604	0	4,604	0.74
	California	14,050				32.77
Guadalupe fur seal	Mexico to California	34,187	2,387	0	2,387	6.98
California sea lion	U.S.	257,606	1140	0	1,140	0.44
Steller sea lion	Eastern U.S.	43,201	7281	0	7,281	16.85

TABLE 10—ESTIMATED TAKING BY LEVEL A AND LEVEL B HARASSMENT, AND PERCENTAGE OF POPULATION—Continued

Species	MMPA stock[a]	Stock abundance	Estimated take		Total proposed take	Percent of MMPA stock
			Level B	Level A		
Phocid Seals:						
Northern elephant seal	California Breeding	179,000	1995	0	1,995	1.11
Harbor seal	Oregon/Washington Coast	[h] 24,732	6537	0	6,537	26.43

[a] In most cases, where multiple stocks are being affected, for the purposes of calculating the percentage of the stock impacted, the take is being analyzed as if all proposed takes occurred within each stock.

[b] Takes are allocated among the three DPSs in the area based on Wade *et al.* (2017) (Oregon: 32.7% Mexico DPS, 67.2% Central America DPS; Washington/British Columbia: 27.9% Mexico DPS, 8.7% Central America DPS, 63.5% Hawaii DPS).

[c] Total for small beaked whale guild. Requested take includes 7 Blainville's beaked whales, 86 Stejneger's beaked whales, 86 Cuvier's beaked whales, and 74 Hubbs' beaked whales (see Appendix B of L–DEO's application for more information).

[d] Proposed take increased to mean group size from Barlow (2016).

[e] Proposed take increased to mean group size from Mobley *et al.* (2000).

[f] Total estimated take is 86 killer whales. Approximately one-third of calculated takes were assigned to each stock due to expected equal likelihood of occurrence in the survey area.

[g] The percentage of these stocks expected to experience take is discussed further in the Small Numbers section later in the document.

[h] As noted in Table 1, there is no current estimate of abundance available for the Oregon/Washington Coast stock of harbor seal. The abundance estimate from 1999, included here, is the best available.

The proposed take numbers shown in Table 10 are expected to be conservative. 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. Also, note that in consideration of the near-field soundscape of the airgun array, we propose to authorize a different number of takes of mid-frequency cetaceans and pinnipeds by Level A harassment than the number proposed by L–DEO (see Appendix B in L–DEO's 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 the activity, and other means of effecting the least practicable impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the 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 the 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 planned surveys include (1) Vessel-based visual mitigation monitoring; (2) Vessel-based passive acoustic monitoring; (3) Establishment of an exclusion zone; (4) Shutdown procedures; (5) Ramp-up procedures; and (6) 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, within which observation of certain marine mammals requires shutdown of the acoustic source, 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 m exclusion zone, out to a radius of 1,000 m from the edges of the airgun array (500–1,000 m). Visual monitoring of the exclusion zone 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 closer 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 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 (discussed below) 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). 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), detections of marine mammals within the buffer zone (but outside the exclusion zone) shall be communicated to the operator to prepare for the potential shutdown of the acoustic source.

During use of the airgun (*i.e.,* anytime the acoustic source is active, including ramp-up), detections of marine mammals within the buffer zone (but outside the exclusion zone) should be communicated to the operator to prepare for the potential shutdown 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.

While the R/V *Langseth* is surveying in water depths of 200 m or less, a second vessel with additional PSOs would travel approximately 5 km ahead of the R/V *Langseth.* Two PSOs would be on watch on the second vessel during all such survey operations and would alert PSOs on the R/V *Langseth* of any marine mammal observations so that they may be prepared to initiate shutdowns.

Visual PSOs on both vessels 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

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 (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 five 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, other than killer whales) 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 five 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. The 500-m EZ would be based on radial distance from the edge 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 criteria of SEL_{cum} 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.

An extended EZ of 1,500 m must be enforced for all beaked whales, and dwarf and pygmy sperm whales. No buffer zone is required.

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 pinnipeds, and 30 minutes for all mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, false killer whales, and Risso's dolphins);
- 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 detection of a marine mammal within the applicable exclusion zone. Once ramp-up has begun, detections of marine mammals within the buffer zone do not require shutdown, but such observation shall be communicated to the operator to prepare for the potential shutdown;
- 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 (*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 minutes 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

The shutdown of an airgun array requires the immediate de-activation of all individual airgun elements of the array. Any PSO on duty will have the authority to delay the start of survey operations or to call for shutdown 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 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 (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. L–DEO must also implement shutdown of the airgun array if killer whale vocalizations are detected, regardless of localization.

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 whales, pygmy sperm whales, dwarf sperm whales, pilot whales, beaked whales, false killer whales, and Risso's dolphins.

The shutdown requirement can be waived for small dolphins if an individual is visually detected within the exclusion zone. As defined here, the small dolphin 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 applies solely to specific genera of small dolphins—*Tursiops, Delphinus, Stenella, Lagenorhynchus, and Lissodelphis.*

We include this small dolphin exception because shutdown requirements for small dolphins under all circumstances represent practicability concerns without likely commensurate benefits for the animals in question. Small dolphins 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 dolphins 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 dolphins, they are much less likely to approach vessels. Therefore, retaining a 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 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.

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).

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 pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, and Risso's dolphins, with no further observation of the marine mammal(s).

L–DEO must implement shutdown if a marine mammal species for which take was not authorized, or a species for which authorization was granted but the takes have been met, approaches the Level A or Level B harassment zones. L–DEO must also implement shutdown if any of the following are observed at any distance:

- Any large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult;
- An aggregation of six or more large whales;
- A North Pacific right whale; and/or
- A killer whale of any ecotype.

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 mysticetes);
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.

Operational Restrictions

While the R/V *Langseth* is surveying in waters 200 m deep or less, survey operations will occur in daylight hours only (*i.e.,* from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure the ability to use visual observation as a detection-based mitigation tool and to implement shutdown procedures for species or situations with additional shutdown requirements outlined above (*e.g.,* killer whale of any ecotype, aggregation of six or more large whales, large whale with a calf).

Communication

Each day of survey operations, L–DEO will contact NMFS Northwest Fisheries Science Center, NMFS West Coast Region, The Whale Museum, Orca Network, Canada's DFO and/or other sources to obtain near real-time reporting for the whereabouts of Southern Resident killer whales.

Mitigation Measures Considered But Eliminated

As stated above, in determining appropriate mitigation measures, NMFS considers the practicability of the measures for applicant implementation, which may include such things as cost or impact on operations. NMFS has proposed expanding critical habitat for Southern Resident killer whales to include marine waters between the 6.1-m depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California (84 FR 49214; September 19, 2019). Though the proposed expansion has not been finalized, due to the habitat features of the area and the higher likelihood of occurrence within the area, NMFS considered implementing a closure area and prohibiting L–DEO from conducting survey operations between the 200-m isobath and the coastline. However, this measure was eliminated from consideration because the closure would not be practicable for L–DEO, as the primary purpose of their proposed survey is to investigate the geologic features that occur within that area. Therefore, NMFS is not proposing to exclude L–DEO from waters within the 200-m isobath for this survey.

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, as well as other measures considered by NMFS described above, 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. During seismic operations, at least five visual PSOs would be based aboard the *Langseth.* Two visual PSOs would be on duty at all time during daytime hours, with an additional two PSOs on duty aboard a second scout vessel at all times during daylight hours when operating in waters shallower than 200 m. 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; and
- 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;
- 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.

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 in the IHA. A final report must be submitted within 30 days following resolution of any comments on the draft report.

Reporting Injured or Dead Marine Mammals

Discovery of 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.

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 shall report the incident to 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 incident;
- 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 measure 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;
- Species identification (if known) or description of the animal(s) involved;
- Estimated size and length of the animal that was struck
- Description of the behavior of the animal immediately preceding and following the strike;
- If available, description of the presence and behavior of any other marine mammals present 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).

Actions To Minimize Additional Harm to Live-stranded (or Milling) Marine Mammals

In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L–DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following: If at any time, the marine mammal the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise the IHA-holder that the shutdown around the animals' location is no longer needed. Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L–DEO that all live animals involved have left the area (either of their own volition or following an intervention).

If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder will be required to determine what measures are necessary to minimize that likelihood (*e.g.,* extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

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, and an investigation into the stranding is being pursued, NMFS will submit a written request to L–DEO 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.

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.

Reporting Species of Concern

To support NMFS's goal of improving our understanding of occurrence of marine mammal species or stocks in the area (*e.g.,* presence, abundance, distribution, density), L–DEO will immediately report observations of Southern Resident killer whales and North Pacific right whales to OPR, NMFS .

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 10 and 11, given that NMFS expects the anticipated effects of the planned 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. As described above, we proposed to authorize only the takes estimated to occur outside of Canadian territorial waters (Table 10); however, for the purposes of our negligible impact analysis and determination, we consider the total number of takes that are anticipated to occur as a result of the entire proposed survey (including the portion of the survey that would occur within the Canadian territorial waters (approximately four percent of the survey) (Table 11).

TABLE 11—TOTAL ESTIMATED TAKE INCLUDING CANADIAN TERRITORIAL WATERS

Species	Estimated take (excluding Canadian territorial waters)		Estimated take (Canadian territorial waters)		Total estimated take	
	Level A	Level B	Level A	Level B	Level B	Level A
LF Cetaceans:						
Humpback whale	172	10	23	1	195	11
Blue whale	63	4	8	0	71	4
Fin whale	89	6	2	0	91	6
Sei whale	32	2	2	0	34	2
Minke whale	105	7	6	0	111	7
Gray whale	90	2	24	1	114	3
MF Cetaceans:						
Sperm whale	71	0	1	0	72	0
Baird's beaked whale	83	0	1	0	84	0
Small beaked whale	244	0	5	0	249	0
Bottlenose dolphin	13	0	0	0	13	0
Striped dolphin	7	0	0	0	7	0
Short-beaked common dolphin	179	0	4	0	183	0
Pacific white-sided dolphin	6,452	0	354	0	6,806	0
Northern right-whale dolphin	4,333	0	123	0	4,457	0
Risso's dolphin	1,906	0	155	0	2,062	0
False killer whale	5	0	5	0	10	0
Killer whale (Southern Resident)	43	0	2	0	45	0
Killer whale (Northern Resident)	27	0	2	0	29	0
Killer whale (West Coast Transient)	26	0	2	0	28	0
Killer whale (Offshore)	26	0	2	0	28	0
Short-finned pilot whale	29	0	1	0	30	0
HF Cetaceans:						
Pygmy/dwarf sperm whale	135	6	8	0	143	6
Dall's porpoise	10,869	452	746	24	11,615	476
Harbor porpoise	12,557	449	2,622	86	15,179	535
Otariid Seals:						
Northern fur seal	4,604	0	58	0	4,662	0
Guadalupe fur seal	2,387	0	122	0	2,509	0
California sea lion	1,140	0	147	0	1,287	0
Steller sea lion	7,281	0	1,342	0	8,623	0
Phocid Seals:						
Northern elephant seal	1,995	0	176	0	2,171	0
Harbor seal	6,537	0	1,744	0	8,281	0

NMFS does not anticipate that serious injury or mortality would occur as a result of L–DEO's planned survey, even in the absence of mitigation, and none would be authorized. As discussed in the *Potential Effects* section, non-auditory physical effects, stranding, and vessel strike are not expected to occur.

We are proposing to authorize a limited number of instances of Level A harassment of nine species (low- and high-frequency cetacean hearing groups only) and Level B harassment of 31 marine mammal species. However, we believe that any PTS incurred in marine mammals as a result of the planned activity would be in the form of only a small degree of PTS, not total deafness, because of the constant movement of relative to each other of both the R/V *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) and, further, would be unlikely to affect the fitness of any individuals. 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 R/V *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, Ellison et al., 2012).

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 (37 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 tracklines of this survey either traverse or are proximal to BIAs for humpback and gray whales (Ferguson *et al.,* 2015). The entire U.S. West Coast within 47 km of the coast is a BIA for migrating gray whale potential presence from January to July and October to December. The BIA for northbound gray whale migration is broken into two phases, Phase A (within 8 km of shore) and Phase B (within 5 km of shore), which are active from January to July and March to July, respectively. The BIA for southbound migration includes waters within 10 km of shore and is active from October to March. There are four gray whale feeding BIAs within the proposed survey area: the Grays Harbor gray whale feeding BIA is used between April and November; the Northwest Washington gray whale feeding BIA is used between May and November; and the Depoe Bay and Cape Blanco and Orford Reef gray whale feeding BIAs off Oregon are each used between June and November. There are also two humpback whale feeding BIAs within the survey area: the Stonewall and Heceta Bank humpback whale feeding BIA off central Oregon and the northern Washington BIA off the Washington Olympic Peninsula are each used between May and November.

For the humpback whale feeding and gray whale feeding and northbound migration BIAs, L–DEO's proposed survey beginning in June 2020 could overlap with a period where BIAs represent an important habitat. However, only a portion of seismic survey days would actually occur in or near these BIAs, and all survey efforts would be completed by mid-July, still in the early window of primary use for these BIAs. Gray whales are most commonly seen migrating northward between March and May and southward between November and January. As proposed, there is no possibility that L–DEO's survey impacts the southern migration, and presence of northern migrating individuals should be below peak during survey operations beginning in June 2020.

Although migrating gray whales may slightly alter their course in response to the survey, the exposure would not substantially impact their migratory behavior (Malme *et al.,* 1984; Malme and Miles 1985; Richardson *et al.,* 1995), and Yazvenko *et al.* (2007b) reported no apparent changes in the frequency of feeding activity in Western gray whales exposed to airgun sounds in their feeding grounds near Sakhalin Island. Goldbogen *et al.* (2013) found blue whales feeding on highly concentrated prey in shallow depths (such as the conditions expected within humpback feeding BIAs) were less likely to respond and cease foraging than whales feeding on deep, dispersed prey when exposed to simulated sonar sources, suggesting that the benefits of feeding for humpbacks foraging on high-density prey may outweigh perceived harm from the acoustic stimulus, such as the seismic survey (Southall *et al.,* 2016). Additionally, L–DEO will shut down the airgun array upon observation of an aggregation of six or more large whales, which would reduce impacts to cooperatively foraging animals. For all habitats, no physical impacts to BIA habitat are anticipated from seismic activities. While SPLs of sufficient strength have been known to cause injury to fish and fish and invertebrate mortality, in feeding habitats, the most likely impact to prey species from survey activities would be temporary avoidance of the affected area and any injury or mortality of prey species would be localized around the survey and not of a degree that would adversely impact marine mammal foraging. 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 expected. Given the short operational seismic time near or traversing BIAs, as well as the ability of cetaceans and prey species to move away from acoustic sources, NMFS expects that there would be, at worst, minimal impacts to animals and habitat within the designated BIAs.

Critical habitat has been established on the U.S. West Coast for the eastern DPS of Steller sea lions (58 FR 45269; August 27, 1993) and in inland waters of Washington for Southern Resident killer whales (71 FR 69054; November 29, 2006). Critical habitat for the Mexico and Central America DPSs of humpback whales has been proposed along the U.S. West Coast (84 FR 54354; October 9, 2019), and NMFS has proposed expanding Southern Resident killer whale critical habitat to include coastal waters of Washington, Oregon, and California (84 FR 49214; September 19, 2019). Only a portion of L–DEO's proposed seismic survey will occur in or near these critical habitats.

Critical habitat for Steller sea lions has been established at two rookeries on the Oregon coast, at Rogue Reef (Pyramid Rock) and Orford Reef (Long Brown Rock and Seal Rock). The critical habitat area includes aquatic zones that extend 0.9 km seaward and air zones extending 0.9 km above these rookeries (NMFS 1993). Steller sea lions occupy rookeries and pup from late-May through early-July (NMFS 2008), which coincides with L–DEO's proposed survey. The Orford Reef and Rogue Reef critical habitats are located 7 km and 9 km from the nearest proposed seismic transect line, respectively. Impacts to Steller sea lions within these areas, and throughout the survey area, are expected to be limited to short-term behavioral disturbance, with no lasting biological consequences.

Critical habitat for the threatened Mexico DPS and endangered Central America DPS humpback whales has been proposed along the U.S. West Coast (84 FR 54354; October 9, 2019). The proposed critical habitat encompasses the humpback whale feeding BIAs described above and generally includes waters between the 50-m isobath and the 1,200-m isobath, though some areas of the proposed critical habitat extend further offshore. NMFS determined that prey within humpback whale feeding areas are essential to the conservation of each of the three DPSs of humpback whales for which critical habitat was proposed (Mexico, Central America, and Western North Pacific DPSs). Critical habitat was therefore proposed in consideration of importance that the whales not only have reliable access to prey within their feeding areas, but that prey are of a sufficient density to support feeding and the build-up of energy reserves. Although humpback whales are generalist predators and prey availability can very seasonally and spatially, substantial data indicate that the humpback whales' diet is consistently dominated by euphausiid species (of genus *Euphausia, Thysanoessa, Nyctiphanes,* and *Nematoscelis*) and small pelagic fishes, such as northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), Pacific sardine (*Sardinops sagax*), and capelin (*Mallotus villosus*) (Nemoto 1957, 1959; Klumov 1963; Rice Krieger and Wing 1984; Baker 1985; Kieckhefer 1992; Clapham *et al.,* 1997; Neilson *et al.,* 2015). While there are possible impacts of seismic activity on plankton and fish species (*e.g.,* McCauley *et al.,* 2017; Hastings and Popper 2005), the areas expected to be affected by L–DEO's activities are small relative to the greater habitat areas available.

Additionally, humpback whales feeding on high-density prey may be less likely to cease foraging when the benefit of energy intake outweighs the perceived harm from acoustic stimulus (Southall *et al.,* 2016). Therefore, this seismic activity is not expected to have a lasting physical impact on humpback whale proposed critical habitat, prey within it, or overall humpback whale fitness. Any impact would be a temporary increase in sound levels when the survey is occurring in or near the critical habitat and resulting temporary avoidance of prey or marine mammals themselves due these elevated sound levels. As stated above, L–DEO will shut down the airgun array upon observation of an aggregation of six or more large whales, which would reduce direct impacts to groups of humpback whales that may be cooperatively feeding in the area.

Southern Resident Killer Whales

In acknowledgment of our concern regarding the status of Southern Resident killer whales, including low abundance and decreasing trend, we address impacts to this stock separately in this section.

L–DEO's proposed tracklines do not overlap with existing Southern Resident killer whale habitat, but NMFS has proposed expanding Southern Resident critical habitat to include waters between the 6.1-m and 200-m depth contours from the U.S. international border with Canada south to Point Sur, California (84 FR 49214; September 19, 2019). The proposed expanded critical habitat areas were identified in consideration of physical and biological features essential to conservation of Southern Resident killer whales (essential features): (1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging. NMFS did not identify in-water sound levels as a separate essential feature of existing or proposed expanded critical habitat areas, though anthropogenic sound is recognized as one of the primary threats to Southern Resident killer whales (NMFS 2019). Exposure to vessel noise and presence of whale watching boats can significantly affect the foraging behavior of Southern Resident killer whales (Williams *et al.,* 2006; Lusseau *et al.,* 2009; Giles and Cendak 2010; Senigaglia *et al.,* 2016). Nutritional stress has also been identified as a primary cause of Southern Resident killer whale decline (Ayres *et al.,* 2012; Wasser *et al.,* 2017), suggesting that reduced foraging effort may have a greater impact than behavioral disturbance alone. However, these studies have primarily focused on effects of whale watch vessels operating in close proximity to Southern Resident killer whales, and commercial shipping traffic in the Salish Sea (*i.e.,* the inland waters of Washington and British Columbia). Commercial whale watch and private recreational vessels operating in the waters around the San Juan Islands in summer months number in the dozens (Erbe 2002), and at least 400 piloted vessels (commercial vessels over 350 gross tons and pleasure craft over 500 gross tons that are required to be guided in and out of the Port of Vancouver by British Columbia Coast Pilots) transit through Haro Strait each month (Joy *et al.,* 2002). Concentration of vessel traffic on the outer coast, where the proposed survey area occurs, is much lower than in the inland waters (Cominelli *et al.,* 2018), suggesting that effects from vessel noise may be lower than in inland waters. Increased noise levels from the proposed survey in any specific area would be short-term due to the mobile nature of the survey, unlike the near-constant vessel presence in inland waters.

Approximately 23 percent of L–DEO's total tracklines occur within the 200-m isobath along Washington and Oregon. L–DEO would be required to shut down seismic airguns immediately upon visual observation or acoustic detection of killer whales of any ecotype at any distance to minimize potential exposures of Southern Resident killer whales, and will operate within the 200-m isobath in daylight hours only, to increase the ability to visually detect killer whales and implement shutdowns. Southern Resident killer whales exposed to elevated sound levels from the R/V *Langseth* and the airgun array may reduce foraging time, but the amount of tracklines that overlap with the areas of highest estimated densities of Southern Resident killer whales (see Figures 7–9 and 7–11 in the U.S. Navy's MSDD (U.S. Navy 2019)) is low relative to the total survey effort. Approximately 360 km of survey tracklines occur within the areas of highest Southern Resident killer whale density (the three highest density ranges for each pod), which represents approximately 5 percent of the total survey tracklines, or just under two days of survey operations. If Southern Resident killer whales are encountered during the survey in these areas and reduce foraging effort in response, the relatively small amount of time of altered behavior would not likely affect their overall foraging ability. While Southern Resident killer whales may be encountered outside of these areas of highest density, the likelihood is significantly decreased and thus the likelihood of impacts to foraging is decreased. Short-term impacts to foraging ability are not likely to result in significant or lasting consequences for individual Southern Resident killer whales or the population as a whole (Ayres *et al.,* 2012). Due to the mobile nature of the survey, animals would not be exposed to elevated sounds for an extended period, and the proposed critical habitat contains a large area of suitable habitat that would allow Southern Resident killer whales to forage away from the survey. Noren *et al.* (2016) reported that although resident killer whales increase energy expenditure in response to vessel presence, the increase is considered to be negligible.

No permanent hearing impairment (Level A harassment) is anticipated or proposed to be authorized. Authorized takes of Southern Resident killer whales would be limited to Level B harassment in the form of behavioral disturbance. We anticipate 45 instances of Level B harassment of Southern Resident killer whales, which we expect would likely occur to a smaller subset of the population on only a few days. Limited, short term behavioral disturbance of the nature expected here would not be expected to result in fitness-level effects to individual Southern Resident killer whales or the population as a whole.

Negligible Impact Conclusions

The proposed survey would be of short duration (37 days of seismic operations), and 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. Short term exposures to survey operations are not likely to significantly disrupt marine mammal behavior, and the potential for longer-term avoidance of important areas is limited.

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 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 to some extent, potential PTS in marine mammals that may otherwise occur in the absence of the proposed mitigation (although all authorized PTS has been accounted for in this analysis). Further, for Southern Resident Killer Whales (as described above), additional mitigation (*e.g.,* second monitoring vessel, daylight only surveys) is expected to increase the ability of PSOs to detect killer whales and shut down the airgun array to reduce the instances and severity of behavioral disturbance.

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, over relatively small areas of the affected animals' ranges. 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 serious injury or mortality is anticipated or proposed to be authorized;
- The proposed activity is temporary and of relatively short duration (37 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;
- The number of instances of potential PTS that may occur are expected to be very small in number. Instances of potential PTS that are incurred in marine mammals are expected to 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 impacts to marine mammal foraging would be minimal; and
- The proposed mitigation measures, including visual and acoustic monitoring, shutdowns, and enhanced measures for areas of biological importance (*e.g.,* additional monitoring vessel, daylight operations only) are expected to minimize potential impacts to marine mammals (both amount and severity).
- Additionally as described above for Southern Resident killer whales specifically, anticipated impacts are limited to few days of behavioral disturbance for any one individual and additional mitigation (*e.g.,* additional monitoring vessel, survey timing, shutdowns) are expected to ensure that both the numbers and severity of impacts to this stock are minimized, and, therefore the proposed authorization of Southern Resident killer whale take is not expected impact the fitness of any individuals, much less rates of recruitment or survival.

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 mitigation and monitoring 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.

There are several stocks for which the estimated instances of take appear high when compared to the stock abundance (Table 10), including the Southern Resident killer whale stock, the California/Oregon/Washington Dall's porpoise stock, and the Northern California/Southern Oregon and Northern Oregon/Washington Coast harbor porpoise stocks. However, when other qualitative factors are used to inform an assessment of the likely number of individual marine mammals taken, the resulting numbers are appropriately considered small. We discuss these in further detail below.

For all other stocks (aside from the four referenced above and described below), the proposed take is less than one-third of the best available stock abundance (recognizing that some of those takes may be repeats of the same individual, thus rendering the actual percentage even lower).

The expected take of Southern Resident killer whales, as a proportion of the population abundance, is 57.33 percent, if all takes are assumed to occur for unique individuals. In their NWTT Phase III MSDD, the U.S. Navy created density estimates of Southern Resident killer whales in their Offshore Study Area (U.S. Navy 2019). These density estimates were developed with the assumption that all members of the Southern Resident population were within the Study Area (*i.e.,* no Southern Resident killer whales were assumed to be in the inland waters of the Salish Sea). In reality, Southern Resident killer whales have historically spent much of their time in the Salish Sea from spring through fall to forage on Fraser River Chinook salmon (Shields *et al.,* 2017) and it is likely that some or all of the population may be in inland waters during the proposed survey. Therefore, we expect that there will be multiple takes of a smaller number of individuals within the action area, such that the number of individuals taken will be less than one-third of the population.

The expected take of the California/Oregon/Washington stock of Dall's porpoises, as a proportion of the population abundance, is 40.8 percent, if all takes are assumed to occur for unique individuals. In reality, it is unlikely that all takes would occur to different individuals. L–DEO's proposed survey area represents a small portion of the stock's overall range (Caretta *et al.,* 2017), and it is more likely that there will be multiple takes of a smaller number of individuals within the action area. In addition, Best *et al.* (2015) estimated the population of Dall's porpoise in British Columbia to be 5,303 porpoises based on systematic line-transect surveys of the Strait of Georgia, Johnstone Strait, Queen Charlotte Sound, Hecate Strait, and Dixon Entrance between 2004 and 2007. In consideration of the greater abundance estimate combining the U.S. stock and animals in British Columbia, and the likelihood of repeated takes of individuals, it is unlikely that more than one-third of the stock would be exposed to the seismic survey.

When assuming all takes of harbor porpoise would occur to either the Northern Oregon/Washington Coast or Northern California/Southern Oregon stocks, the take appears high relative to stock abundance (60.53 and 36.36 percent, respectively). In reality, takes will occur to both stocks, and therefore, the number of takes of each stock will be much lower. NMFS has no commonly used method to estimate the relative proportion of each stock that would experience take, but here we propose to apportion the takes between the two stocks based on the stock boundary (Lincoln City, Oregon) and the approximate proportion of the survey area that will occur on either side of the stock boundary. North of Lincoln City, Oregon, harbor porpoises belong to the Northern Oregon/Washington Coast stock, and south of Lincoln City, harbor porpoises belong to the Northern California/Southern Oregon stock. Approximately one-third of the proposed survey occurs south of Lincoln City, therefore one-third of the total estimated takes are assumed to be from the Northern California/Southern Oregon stock. The remaining two-thirds of the estimated takes are assumed to be from the Northern Oregon/Washington Coast stock. The estimated one-third of total takes assigned to the Northern California/Southern Oregon stock (4,335 total Level A and Level B takes) represent 12.12 percent of the stock abundance, which NMFS considers to be small relative to the stock abundance. In addition, the proposed survey area represents a small portion of the stock's range, and it is likely that there will be multiple takes of a small portion of individuals, further reducing the number of individuals exposed. The estimated two-thirds of total takes assigned to the Northern Oregon/Washington Coast stock (8,671 takes) represent 40.35 percent of the stock abundance, which is still considered high relative to stock abundance. However, the Northern Oregon/Washington Coast stock abundance estimate does not include animals in Canadian waters (Caretta *et al.,* 2017). Best *et al.* (2015) estimated a population abundance of 8,091 harbor porpoises in British Columbia. The estimated takes of animals in the northern portion of the survey area (north of Lincoln City) represent 29.32 percent of the combined British Columbia and Northern Oregon/Washington Coast abundance estimates, which NMFS considers to be small relative to estimated abundance.

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

NMFS is proposing to authorize take of blue whales, fin whales, sei whales, sperm whales, Central America DPS humpback whales, Mexico DPS humpback whales, Southern Resident killer whale DPS, and Guadalupe fur seal, which are listed under the ESA. The NMFS Office of Protected Resources (OPR) Permits and Conservation Division has requested initiation of Section 7 consultation with the NMFS OPR ESA 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 beginning in June 2020, 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 the proposed geophysical survey. We also request at this time comment on the potential 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 decisions on the request for this IHA or a subsequent Renewal IHA.

On a case-by-case basis, NMFS may issue a one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA);

- The request for renewal must include the following:

(1) An explanation that the activities to be conducted under the requested Renewal IHA 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); 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: April 1, 2020.

Donna S. Wieting,

Director, Office of Protected Resources, National Marine Fisheries Service.

[FR Doc. 2020–07289 Filed 4–6–20; 8:45 am]

BILLING CODE 3510–22–P