Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during Marine Geophysical Surveys by R/V *Marcus G. Langseth* off Western Mexico, Eastern Tropical Pacific Ocean

submitted by

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to

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TABLE OF CONTENTS

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SUMMARY

Researchers from the New Mexico Institute of Mining and Technology (New Mexico Tech or NMT) and University of New Mexico (UNM), with funding from the National Science Foundation (NSF), and in collaboration with Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), propose to conduct marine geophysical research in the Eastern Tropical Pacific (ETP) off Mexico (Proposed Action). The research would include low-energy seismic surveys and heat probe measurements conducted from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned and operated by Lamont-Doherty Earth Observatory (L-DEO) of Columbia University. The proposed two-dimensional (2-D) seismic surveys would use a cluster of two Generator Injector (GI) airguns with a total discharge volume of approximately (~) 90 in^3. The research would occur within the Mexican Exclusive Economic Zone (EEZ) but outside of territorial waters, in water 1000 m to 5300 m deep.

Numerous species of marine mammals managed by the National Marine Fisheries Service (NMFS) inhabit the proposed survey area in the ETP. Under the U.S. ESA, several of these species are listed as ***endangered***, including the sei, fin, blue, and sperm whale, and the Central America Distinct Population Segment (DPS) of the humpback whale. The ***threatened*** Mexico DPS of the humpback whale could possibly occur in the proposed project area, as well as the ***threatened*** Guadalupe fur seal. Thus, this request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371(a)(5).

ESA-listed sea turtle species that could occur in the proposed survey area include the ***endangered*** leatherback, hawksbill turtle, and Mexico's Pacific coast breeding population of olive ridley turtles, and the North Pacific Ocean DPS of loggerhead turtles, and the ***threatened*** East Pacific DPS of the green turtle. ESA-listed fish that could occur in the area include the ***endangered*** Eastern Pacific DPS of scalloped hammerhead shark, and the ***threatened*** oceanic whitetip shark and giant manta ray. ESA-listed seabirds that could be encountered in the area include the ***endangered*** California least tern.

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

I. Operations to be Conducted

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

Overview of the Activity

Low-energy seismic surveys with two 45 in^3 generator injector (GI) airguns would be used to obtain information on the sediment distribution and geologic structure of the Cocos plate and margin wedge, which is necessary for constraining the thermal structure of the subduction zone offshore southern Mexico. The main goal of the geophysical research proposed by the principal investigator (PI) Dr. G. Spinelli (NMT) and Co-PI Dr. L. Worthington (UNM) is to acquire 2-D seismic reflection data, in conjunction with densely spaced heat probe measurements, to quantify the effects of fluid circulation in oceanic crust on temperatures in the southern Mexico subduction zone. The proposed surveys would occur within ~15.5–17°N and 99.5–102°W off the Pacific coast of Mexico; representative survey tracklines are shown in Figure 1. The surveys are proposed to occur within the Exclusive Economic Zone (EEZ) of Mexico in water 1000 m to 5300 m deep.

The low-energy surveys would involve one source vessel, R/V *Langseth*, which would tow a two GI-airgun array at a depth of 3 m; the total discharge volume would be ~90 in^3. The GI airgun cluster would fire at a shot interval of 6.25–12.5 m (2.4–4.9 s) during seismic acquisition. The main receiving system would consist of a 3 to 5-km long solid-state hydrophone streamer (solid flexible polymer – not gel or oil filled). As the airgun array is towed along the survey lines, the hydrophone streamer would transfer the data to the on-board processing system.

In addition to the operations of the airgun array, other acoustic sources, including a multibeam echosounder (MBES), sub-bottom profiler (SBP) and an Acoustic Doppler Current Profiler (ADCP) would be operated from R/V *Langseth* continuously during the seismic surveys. During heat flow probe operations, a 12-kHz bottom-finding pinger would be employed, and an acoustic release would be used once during an initial calibration of the heat probe activities. All planned marine-based geophysical data acquisition activities would be conducted by L-DEO with on-board assistance by the scientists who have proposed the studies. The vessel would be self-contained, and the crew would live aboard the vessel.

Source Vessel Specifications

R/V *Marcus G. Langseth* is described in § 2.2.2.1 of the Final Programmatic Environmental Impact Statement (PEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Records of Decision (NSF 2012; USGS 2013) referred to herein as the PEIS. The vessel speed during seismic operations with the two GI airgun array would be ~4.5–5 kt (~8.3–9.3 km/h). When R/V *Langseth* is towing the airgun array and hydrophone streamer, the turning rate of the vessel is limited to five degrees per minute. Thus, the maneuverability of the vessel is limited during operations with the streamer.

Airgun Description

During the surveys, R/V *Langseth* would tow a 2 GI-airgun cluster in true GI (45/105) mode as the seismic source, with a total discharge volume of 90 in^3. The two inline GI airgun would be spaced 2.46 m apart. The array would be towed at a depth of 3 m, and the shot interval would be 6.25–12.5 m (2.4 to 4.9 s). During firing, a brief pulse of sound with a duration of ~0.1 s would be emitted. The airguns would be silent during the intervening periods. During operations, the GI airguns would be operated 24/7 for multiple days to meet science objectives unless maintenance or mitigation measures warranted.

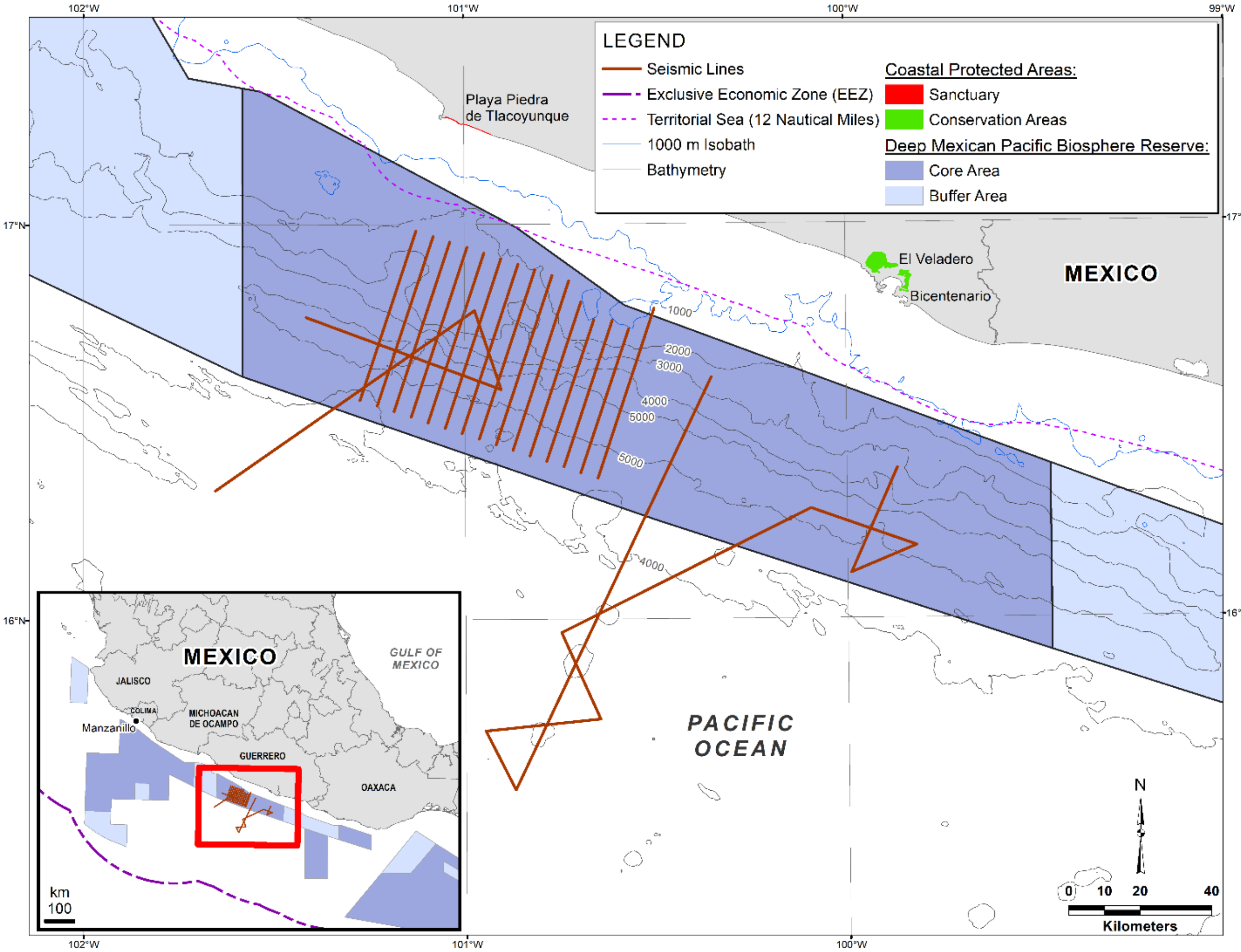

FIGURE 1. Location of the proposed seismic surveys in the Eastern Tropical Pacific Ocean off the west coast of Mexico.

GI Airgun Specifications

Energy Source:	Two GI guns of 45/105 in^3 each
Gun positions used:	Two inline airguns 2.46 m apart
Towing depth of energy source:	3 m
Source output (2.46-m gun separation):	0-peak is 3.6 bar-m (231.1 dB re 1 µPa·m); peak-peak is 7.1 bar-m (237.0 dB re 1 µPa·m)
Air discharge volume:	Approx. 90 in^3
Dominant frequency components:	0–188 Hz
Gun volumes at each position (in^3):	45, 45
Firing Pressure	~2000 psi

The source levels for the airgun arrays can be derived from the modeled farfield source signature, which is estimated using the PGS Nucleus software. The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the airgun array. The actual received level at any location in the water near the airguns would not exceed the source level of the strongest individual source. Actual levels experienced by any organism more than 1 m from the airguns would be significantly lower.

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

Mitigation zones for the proposed seismic surveys were not derived from the farfield signature but calculated based on modeling by L-DEO for the exclusion zones (EZ) for Level A takes and for the Level B (160 dB re 1μPa_{rms}) threshold. However, Level A takes would not be anticipated and therefore were not requested. The background information and methodology for the modeling are provided in Appendix A. L-DEO model results are used to determine the 160-dB_{rms} radius for airgun sources down to a maximum depth of 2000 m (see Appendix A), as animals are generally not anticipated to dive below 2000 m (Costa and Williams 1999).

Table 1 shows the distances at which the 160-dB re 1μPa_{rms} sound levels are expected to be received for two GI airgun array. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals. Table 1 also shows the distances at which the 175-dB re 1μPa_{rms} sound level is expected to be received for the various airgun sources; this level is used by NMFS, based on US DoN (2017a), to determine behavioral disturbance for sea turtles.

This document has been prepared in accordance with the current National Oceanic and Atmospheric Administration (NOAA) acoustic practices, and the monitoring and mitigation procedures are based on best practices (e.g., Pierson et al. 1998; Weir and Dolman 2007; Nowacek et al. 2013a; Wright 2014; Wright and Cosentino 2015; Acosta et al. 2017; Chou et al. 2021). Although Level A takes would not be anticipated, for other recent low-energy seismic surveys, NMFS required protected species observers (PSOs) to establish and monitor a 100-m exclusion zone (EZ) and a 200-m buffer zone beyond the EZ. Shut downs would be implemented for marine mammals within the designated EZ. A shut down would also be implemented for sea turtles or diving ESA-listed seabirds. A 100-m EZ would be used for shut downs of the GI airguns for sea turtles and seabirds. Enforcement of mitigation zones via shut downs would be implemented as described below. Enforcement of mitigation zones via shut downs would be implemented as described in § XI or as otherwise required by regulators.

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

TABLE 1. Predicted distances to behavioral disturbance sound levels ≥160-dB re 1 μPa$_{rms}$ and ≥175-dB re 1 μPa$_{rms}$ that could be received during the proposed surveys in the ETP off Mexico, based on modeling. The 160-dB criterion applies to all hearing groups of marine mammals (Level B harassment), and the 175-dB criterion applies to sea turtles.

Source and Volume	Tow Depth[1] (m)	Water Depth (m)	Predicted distances (in m) to the 160-dB Received Sound Level[2]	Predicted distances (in m) to the 175-dB Received Sound Level[2]
Two 45/105 in^3 GI airguns	3	>1000 m	438	78

Heat Flow Probe Measurement Description

Heat flow data would be acquired with a heat flow probe from the U.S. Marine Heat Flow Capability. The heat probe is a passive system that takes the temperature of the sediments like a thermometer. Heat probe lengths are typically 3.5 and 6 m, and the weight in water is ~0.5 tons. Heat probe measurements are made by lowering the probe through the water column and letting it plunge ~3.5 m into the sediment. Measurements consist of two parts — thermal gradient and conductivity — and would be made every ~500–1000 m. At each measurement, site the probe is left in the seafloor for ~15 minutes. After the measurement is taken, the probe is pulled out of the sediment and raised ~ 200 m above the seafloor, the ship then moves position along the transect, and the process is repeated (referred to as “pogo” mode). An acoustic release would be used once during an initial calibration of the heat probe activities. The heat probe would be deployed over the side of the vessel using standard oceanographic techniques and wire. The vessel would be on station when the probe is deposited into the sediment and would move very slowly during transits with towed gear (~1 to 1.5 knots). The weight of the towed gear would keep the wire taught. An acoustic release would be used once during an initial calibration of the heat probe activities.

The heat flow probe would be equipped with an ultra-short baseline (USBL) transducer acoustic positioning system (or pinger) to allow it to “talk” with the research vessel. During heat flow operations, a 12-kHz bottom-finding pinger would be used. The pole-mounted USBL transducer pings once per second to the receiver to locate the heat flow probe location and vice versa. The reflected pings are picked up by the Knudsen SBP. The forward beam pattern is 55 degrees, and the output level is +93 dB minimum forward level and +85 dB minimum back level (levels referenced to one microbar at one yard), with a pulse length of 0.5, 2 or 10 milliseconds. While on station for heat flow measurements, the MBES would be turned off.

Description of Operations

The procedures to be used for the proposed marine geophysical surveys would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Langseth*, which would tow two 45 in^3 GI airguns with a discharge volume of ~90 in^3 at a depth of 3. The main receiving system would consist of a 3 to 5-km long solid-state hydrophone streamer. As the airgun array is towed along the survey lines, the hydrophone streamer would transfer the data to the on-board processing system.

The surveys would consist of ~1258 km of seismic acquisition (see Fig. 1). All effort would occur in water more than 1000 m deep. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the take calculations (see Section VII), 25% has been added in the form of operational days which is equivalent to adding 25% to the proposed line km to be surveyed.

In addition to the operations of the airgun array, the ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. A Teledyne RDI 75 kHz Ocean Surveyor ADCP would be used to measure water current velocities. These sources are described in § 2.2.3.1 of the PEIS and Section 2.1.2.7 of the associated Draft Environmental Analysis.

II. DATES, DURATION, AND REGION OF ACTIVITY

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

The proposed marine seismic surveys would occur within ~15.5–17°N and 99.5–102°W; representative survey tracklines are shown in Figure 1. As described further in this document, however, some deviation in actual tracklines, including the order of survey operations, could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Thus, for the surveys, the tracklines could occur anywhere within the coordinates noted above. The surveys are proposed to occur in the ETP within the EEZ of Mexico in water depths ranging from 1000 to 5300 m. The proposed survey would take place at least 30 km off the coast of Mexico.

The proposed low-energy surveys with the two GI airguns would be expected to take place during spring 2025 (currently scheduled for May 25 – June 17, 2025) for a period of ~24 days; this includes 7 days of seismic operations, 14 days of heat flow probe measurements, and 3 days of transit. R/V *Langseth* would likely leave out of and return to port in Manzanilla, Mexico (~420 km north of the survey area).

III. SPECIES AND NUMBERS OF MARINE MAMMALS IN AREA

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

Thirty marine mammal species could occur in or near the proposed survey area, including 6 mysticetes (baleen whales), 22 odontocetes (toothed whales, such as dolphins), and 2 pinnipeds (seals and sea lions) (Table 2). Several species that could occur in the proposed survey area are listed under the U.S. ESA as ***endangered***, including the sei, fin, blue, sperm, and Central America DPS of humpback whale. The ***threatened*** Mexico DPS of the humpback whale could possibly occur in the proposed project area. To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below. Although the ***threatened*** Guadalupe fur seal is unlikely to occur in the survey area, it is included in the species descriptions below.

Another 11 cetacean species that occur in the Northeast Pacific Ocean are unlikely to occur in the proposed survey area and are not discussed further, including the North Pacific right whale (*Eubalaena japonica*), gray whale (*Eschrichtius robustus*), Hubbs' beaked whale (*Mesoplodon carlhubbsi*), Stejneger's beaked whale (*M. stejnegeri*), Perrin's beaked whale (*M. perrini*), Baird's beaked whale (*Berardius bairdii*), vaquita (*Phocoena sinus*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and northern right whale dolphin (*Lissodelphis borealis*). Two of the six species of pinnipeds – the California sea lion and Guadalupe fur seal – known to occur in the ETP could potentially occur in the proposed project. The remaining five pinniped species known from the ETP – Galápagos sea lion (*Zalophus wollebaeki*), Galápagos fur seal (*Arctocephalus galapagoensis*), South American fur seal (*A. australis*), South American sea lion (*Otaria flavescens*), and northern elephant seal (*Mirounga angustirostris*) – are not expected to occur in the survey area.

TABLE 2. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic survey area off the Pacific coast of Mexico.

Species	Occurrence in Study Area during Survey[1]	Habitat	Abundance			Conservation Status			
			North Pacific	ETP[2]	Mexico Pacific[3]	U.S. ESA[4]	Mexico[5]	IUCN[6]	CITES[7]
Mysticetes									
Humpback whale	Uncommon	Mainly nearshore, banks	1496[8] 3477[9] 21,063[10]	2566	-	EN/T[25]	Pr	LC	I
Common minke whale	Uncommon	Coastal, pelagic	20,000[11]	115	-	NL	Pr	LC	I
Bryde's whale	Uncommon	Coastal, pelagic	-	10,411	649	NL	Pr	LC	I
Sei whale	Rare	Mostly pelagic	29,600[12]	0	-	EN	Pr	EN	I
Fin whale	Rare	Slope, pelagic	13,620-18,680[13]	574	145	EN	Pr	VU	I
Blue whale	Uncommon	Coastal, pelagic	2500[14]	1415	773	EN	Pr	EN	I
Odontocetes									
Sperm whale	Uncommon	Pelagic, steep topography	-	4145	2810	EN	Pr	VU	I
Pygmy sperm whale	Rare	Deeper waters off shelf	4111[15]	-	-	NL	Pr	LC	II
Dwarf sperm whale	Uncommon	Deeper waters off shelf	-	11,200[16]	-	NL	Pr	LC	II
Cuvier's beaked whale	Uncommon	Pelagic	90,725[17]	20,000[18]	68,828[19]	NL	Pr	LC	II
Longman's beaked whale	Rare	Pelagic	291[17]	1007	-	NL	NL	LC	II
Blaineville's beaked whale	Rare	Pelagic	32,678[20]	25,300[21]	68,828[19]	NL	Pr	LC	II
Ginkgo-toothed beaked whale	Rare	Pelagic	32,678[20]	25,300[21]	68,828[19]	NL	Pr	DD	II
Deraniyagala's beaked whale	Rare	Pelagic	32,678[20]	25,300[21]	68,828[19]	NL	NL	DD	II
Pygmy beaked whale	Uncommon	Pelagic	32,678[20]	25,300[21]	68,828[19]	NL	Pr	LC	II
Risso's dolphin	Uncommon	Shelf, slope, seamounts	-	110,457	24,084	NL	Pr	LC	II
Rough-toothed dolphin	Uncommon	Mainly pelagic	-	107,663	37,511	NL	Pr	LC	II
Common bottlenose dolphin	Common	Coastal, shelf, pelagic	-	335,834	61,536	NL	Pr	LC	II
Pantropical spotted dolphin	Common	Coastal and pelagic	-	1,297,092[22]	146,296	NL	Pr	LC	II
Spinner dolphin	Common	Coastal and pelagic	-	2,075,871[22]	186,906	NL	Pr	LC	II
Striped dolphin	Common	Off continental shelf	-	964,362	128,867	NL	Pr	LC	II

Species	Occurrence in Study Area during Survey[1]	Habitat	Abundance			Conservation Status			
			North Pacific	ETP[2]	Mexico Pacific[3]	U.S. ESA[4]	Mexico[5]	IUCN[6]	CITES[7]
Common dolphin	Common	Shelf, pelagic, seamounts	-	3,127,203	283,196	NL	Pr	LC	II
Fraser's dolphin	Uncommon	Pelagic	-	289,300[18]	-	NL	Pr	LC	II
Short-finned pilot whale	Uncommon	Pelagic, high-relief	-	589,315[23]	3348	NL	Pr	LC	II
Killer whale	Uncommon	Widely distributed	-	8500[18]	852	EN	Pr	DD	II
False killer whale	Uncommon	Pelagic	-	39,800[18]	-	NL	Pr	NT	II
Pygmy killer whale	Uncommon	Pelagic	-	38,900[18]	-	NL	Pr	LC	II
Melon-headed	Rare	Pelagic	-	45,400[18]	-	NL	Pr	LC	II
Pinnipeds									
Guadalupe fur seal	Rare	Mainly coastal,	34,187[24]	-	-	T	P	LC	I
California sea lion	Uncommon	Coastal	257,606[15]	105,000	-	NL	Pr	LC	N.A.

- not available or not applicable.

[1] Occurrence in area at the time of the survey and in deep water; based on professional opinion and available data, including densities.

[2] Abundance for the ETP from NMFS (2015) unless otherwise stated.

[3] Pacific Mexico (excluding Gulf of California) from Gerrodette and Palacios (1996) unless otherwise indicated.

[4] U.S. Endangered Species Act (ESA; NOAA 2024a): EN = Endangered; T = Threatened; NL = Not listed.

[5] Norma Oficial Mexicana NOM-059-SEMARNAT-2010: P = En peligro de extinción (in danger of extinction); Pr = Sujetas a protección especial (subject to special protection).

[6] International Union for the Conservation of Nature Red List of Threatened Species, version 2024-1 (IUCN 2024): EN = Endangered; VU = Vulnerable; LC = Least Concern; NT = Near Threatened; DD = Data Deficient.

[7] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2024): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.

[8] Central America/Southern Mexico – CA-OR-WA stock (Carretta et al. 2023).

[9] Mainland Mexico – CA-OR-WA (Carretta et al. 2023).

[10] North Pacific (Barlow et al. 2011).

[11] Northwest Pacific and Okhotsk Sea for 2003 (IWC 2024a).

[12] Central and Eastern North Pacific (IWC 2024a).

[13] North Pacific (Ohsumi and Wada 1974).

[14] Eastern North Pacific (IWC 2024a).

[15] Abundance for U.S. West coast (Carretta et al. 2023).

[16] Estimate for ETP is mostly for *K. sima* but may also include some *K. breviceps* (Wade and Gerrodette 1993).

[17] Eastern North Pacific (Ferguson and Barlow 2001 *in* Barlow et al. 2006).

[18] Wade and Gerrodette (1993).

[19] All ziphiids.

[20] This estimate for the Eastern North Pacific includes all species of the genus *Mesoplodon* (Ferguson and Barlow 2001 *in* Barlow et al. 2006).

[21] This estimate for the ETP includes all species of the genus *Mesoplodon* (Wade and Gerrodette 1993).

[22] Includes several stocks added together.

[23] Based on surveys in 2000 (Gerrodette and Forcada 2002)

[24] Entire population from Mexico to California (Carretta et al. 2023).

[10] Central America DPS is endangered, and the Mexico DPS is threatened; based on information in Carretta et al. (2023), the Central America DPS is most likely to occur in the proposed survey area.

IV. STATUS, DISTRIBUTION AND SEASONAL DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

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

Sections III and IV are integrated here to minimize repetition. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. Two of the detailed analysis areas (DAAs) defined in the PEIS occur near the proposed survey area—Southern California is located north of the proposed survey area, and the Galapagos Ridge is located south of the survey area. The general distribution of mysticetes, odontocetes, and pinnipeds in these areas is discussed in § 3.6.2, § 3.7.2, and § 3.8.2 of the PEIS, respectively.

The most extensive regional distribution and abundance data that encompass the entire study area come primarily from multi-year vessel surveys conducted in the wider ETP by the NMFS Southwest Fisheries Science Center (SWFSC). Ferguson and Barlow (2001) reported on data collected from 1986–1996, and Forney et al. (2012) used SWFSC data collected during 1986–2006 to develop species-habitat models for the ETP. Initial systematic studies of cetaceans in the ETP were prompted by the incidental killing of dolphins in the purse-seine fishery for yellowfin tuna in the area (Smith 1983). Hundreds of thousands of dolphins used to be killed in the tuna fishery annually, the bycatch has been drastically reduced to <0.05% of the population size of each ETP dolphin stock (Bayliff 2004). The main cetacean species that were affected by the fishery are pantropical spotted and spinner dolphins (Smith 1983). Short-beaked common, striped, bottlenose, Fraser's, and rough-toothed dolphins, as well as short-finned pilot whales, have also been killed in the fishery (e.g., Hall and Boyer 1989). Dolphin mortality was high at the onset of the fishery (Allen 1985), but has since dropped considerably (Hall 1998). During the 1960s, it was estimated that 200,000–500,000 dolphins per year were killed by the fishery (Wade 1995).

In 1992, the La Jolla Agreement provided a framework to reduce the mortality by setting dolphin mortality limits (DML) for fishing vessels (AIDCP 2024). The Agreement on the International Dolphin Conservation Program (AIDCP) formalized the provisions of the La Jolla Agreement and entered into force in 1999. The Parties to the AIDCP "committed to ensure the sustainability of tuna stocks in the eastern Pacific Ocean and to progressively reduce the incidental dolphin mortalities in the tuna fishery of the eastern Pacific Ocean to levels approaching zero and to avoid, reduce and minimize the incidental catch and the discard of juvenile tuna and the incidental catch of non-target species, taking into consideration the interrelationship among species in the ecosystem".

The total DML was 5000 animals for 2019 and 2020 (AIDCP 2024). The bycatch was reported as 778 animals in 2019 and 819 animals in 2018, and has been <1000 since 2011 (AIDCP 2024). Populations of offshore spotted dolphins and eastern spinner dolphins had not recovered by the early 2000s (Gerrodette and Forcada 2005; Wade et al. 2007). It is currently unknown whether these populations have recovered, as current population estimates are unknown (Leslie and Morin 2016); no systematic surveys have taken place since 2006 (Scott et al. 2018). However, Oedekoven et al. (2021) conducted a trial survey for ETP dolphins off the west coast of Mexico in November 2019, and a main survey is proposed for the future. The goal of a future main survey is to estimate the current abundance of dolphins in the ETP. The trial survey mainly tested the use of a drone to assess whether they can be used to detect dolphin schools ahead of the vessel, and whether they can be used to determine school size and species composition. Sighting information from the trial survey is included in the species accounts below.

Mysticetes

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all oceans of the World (Clapham 2018). Based on genetic data, there could be three subspecies, occurring in the North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). Nonetheless, genetic analyses suggest some gene flow (either past or present) between the North and South Pacific (e.g., Jackson et al. 2014; Bettridge et al. 2015). Although considered to be mainly a coastal species, humpback whales often traverse deep pelagic areas while migrating (Calambokidis et al. 2001; Garrigue et al. 2002, 2015; Zerbini et al. 2011). Humpbacks 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; Bettridge et al. 2015). Humpbacks winter in four different breeding areas: (1) the coast of Mexico; (2) the coast of Central America; (3) around the main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Calambokidis et al. 2008; Bettridge et al. 2015). These breeding areas are recognized as the Mexico, Central America, Hawaii, and Western Pacific DPSs, but feeding areas have no DPS status (Bettridge et al. 2015; NMFS 2016a). Individuals encountered in the proposed survey area at the time of the survey would most likely be from the Central America DPS as they move northward (see Steiger et al. 1991; Calambokidis et al. 2008; Martien et al. 2021; Martínez-Loustalot et al. 2021; Carretta et al. 2023); however, it is possible that some individuals could belong to the Mexico DPS (Martien et al. 2021).

NMFS recently evaluated the North Pacific DPSs with respect to demographically independent populations (DIPs) and “units” that contain one or more DIPs (Martien et al. 2021; Taylor et al. 2021; Wade et al. 2021; Oleson et al. 2022). Based on these DIPs and units, NMFS has designated five stocks including: the Central America/Southern Mexico – California/Oregon/Washington stock (part of the Central America DPS), the Mainland Mexico – California/Oregon/Washington and Mexico-North Pacific stocks (part of the Mexico DPS), the Hawai’i stock, and the Western North Pacific stock (Carretta et al. 2023).

Whales in the Central America/Southern Mexico – CA-OR-WA stock winter off the coasts of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica, and southern Mexico including the states of Oaxaca and Guerrero, with some animals ranging even farther north (Taylor et al. 2021); they summer off California, Oregon, and Washington (Calambokidis et al. 2017). Whales from the Mainland Mexico – CA-OR-WA stock mainly winter off the Mexican state of Nayarit and Jalisco, with some animals occurring as far south as Colima and Michoacán; this stock summers off California, Oregon, Washington (Martien et al. 2021), as well as southern B.C., Alaska, and the Bering Sea. The Mexico – North Pacific stock winters off Mexico and the Revillagigedo Archipelago, and most individuals summer in Alaska (Martien et al. 2021).

In the Mexican Pacific, there are three main locations where humpbacks aggregate including the southern end of Baja California, the central portion of the mainland, and the Revillagigedo Archipelago; they also aggregate in the northern Gulf of California (Urbán and Aguayo 1987; Urbán et al. 2000). Most northeastern Pacific humpbacks spend the northern winter off the Baja California Peninsula and mainland Mexico, and summer off the western coast of North America from California to Alaska (Urbán and Aguayo 1987; Urbán et al. 2000). While on wintering grounds, humpbacks occur predominantly in coastal waters. The Northern Hemisphere humpbacks occur in the Mexican Pacific from as early as September through the winter to mid-May (Urbán and Aguayo 1987). However, they have been reported in the Gulf of California throughout the year (Bean et al. 1999 *in* Heckel et al. 2020), so it is likely that not all whales undergo the migration (Guerrero et al. 2006). Urbán et al. 1999 (*in* Heckel et al. 2020) provided an abundance estimate of 1813 individuals for the Gulf of California in 1992, and 914 whales for the Revillagigedo Archipelago in 1991. In the Mexican Pacific, humpbacks appear to prefer waters <200 m deep (Urbán and Aguayo 1987).

During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 10 sightings of humpback whales were made (Gerrodette and Palacios 1996). Based on July–December 1986–1996 surveys, the density of humpback whales in the proposed project area was zero (Ferguson and Barlow 2001). However, 403 sightings were made near the proposed project area from 1981–1986, including in nearshore waters off Jalisco, Colima, Guerrero, and Oaxaca; most sightings were made from December through February (Urbán and Aguayo 1987). Jackson et al. (2004) did not encounter any humpbacks in the proposed study area or anywhere off the coast of Mexico during surveys in July–December 2003.

Nine sightings were made during surveys off the Pacific coast of Mexico in November 2019; the mean group size was one (Oedekoven et al. 2021). The central coast of Oaxaca is thought to be a migratory corridor during winter, with whales typically migrating up to 4 km from shore (Heckel et al. 2020). In 2012, 45 sightings were made off Oaxaca (Castillejos-Moguel and Villegas-Zurita 2014 *in* Heckel et al. 2020) including feeding behavior (Villegas-Zurita and Castillejos-Moguel 2013 *in* Heckel et al. 2020). Feeding has also been observed in Banderas Bay, which is known to be an aggregation area for humpbacks during the winter months (Frish-Jordán et al. 2019). One sighting was made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). There are nearly 1000 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; nearly all sightings were made from December through March (OBIS 2024). Although sightings are regularly made within the region during winter, sightings during the proposed late spring survey in deep offshore waters are likely to be uncommon.

Common Minke Whale (*Balaenoptera acutorostrata scammoni*)

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 south to within 2º of the Equator (Perrin et al. 2018). The International Whaling Commission (IWC) recognizes three stocks of minke whales in the North Pacific: the Sea of Japan/East China Sea, the rest of the western Pacific west of 180ºN, and the remainder of the Pacific (Donovan 1991).

Although the general distribution of minke whales includes Mexico, and they are known to occur off the Baja California Peninsula year-round (Heckel et al. 2020), minke whales are likely to be uncommon to rare in the survey area. Rankin and Barlow (2005) reported acoustic recordings of minke whale calls (boings) between 15° and 35°N in the central and eastern North Pacific Ocean; eastern-type 'boings' were recorded off the coast of Mexico, including near the northern part of the proposed survey area. Arroyo (2017) reported the presence of this species Banderas Bay, just north of the proposed survey area, and González et al. (2008) also noted its presence off the Pacific coast of Mexico, south of 18°N.

During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, eight sightings of minke whales were made (Gerrodette and Palacios 1996). However, all sightings were made off the Baja California Peninsula, and no minke whales were seen in the proposed project area over a 10-year period by Ferguson and Barlow (2001).

Similarly, during July–December 2003 surveys by Jackson et al. (2004), no minke whales were encountered in the study area; a single minke whale sighting was made off Baja California. RPS (2022) reported four sightings of single individuals were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022. There are no sightings in or near the proposed study area in the OBIS database, but there are two records for the far offshore waters off Mexico; these sightings were made in November between 14.8°–17.2°N and 112.5°–115.5°W (OBIS 2024).

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

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2018). It is one of the least known large baleen whales, and it remains uncertain how many species are represented in this complex (Kato and Perrin 2018). *B. brydei* is commonly used to refer to the larger form or "true" Bryde's whale and *B. edeni* to the smaller form; however, some authors apply the name *B. edeni* to both forms (Kato and Perrin 2018). Bryde's whale remains in warm (>16°C) water year-round, although seasonal movements have been recorded towards the Equator in winter and offshore in summer (Kato and Perrin 2018). However, Debrot (1998) noted that this species is sedentary in the tropics. Bryde's whales are known to occur in both shallow coastal and deeper offshore waters (Jefferson et al. 2015).

In the Pacific U.S., a Hawaii and an ETP stock are recognized (Carretta et al. 2021). Bryde's whales are known to occur along the entire coast of Mexico, including the Gulf of California (Heckel et al. 2020) and Banderas Bay (Arroyo 2017 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 12 sightings of B. *edeni* were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 649 *B. edeni* for the EEZ of Pacific Mexico. Based on July–December 1986–1996 surveys, the density of Bryde's whales in the proposed project area was 0.0001/km^2 and ranged up to 0.0003/km^2 in adjacent waters (Ferguson and Barlow 2001). Sightings were made north and south of the study area during surveys in 1998–2000 (Forney et al. 2012). One sighting was made near the northern part of the proposed survey area during July–December surveys in 2003; additional sightings were reported off the Baja California Peninsula, including the Gulf of California (Jackson et al. 2004). Four sightings of single sei/Bryde's whales were made during surveys off the Pacific coast of Mexico during November 2019 (Oedekoven et al. 2021). Two sightings of individual Bryde's whales were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). There are five sightings in the OBIS database for the waters in and adjacent to the proposed survey; the sightings were made during September and November (OBIS 2024).

Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins (Horwood 2018), but appears to prefer mid-latitude temperate waters (Jefferson et al. 2015). It undertakes seasonal migrations to feed in subpolar latitudes during summer and returns to lower latitudes during winter to calve (Horwood 2018). On summer feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry et al. 1999). In the North Pacific during summer, the sei whale can be found from the Bering Sea to the Gulf of Alaska and down to the Baja California Peninsula, as well as in the western Pacific from Japan to Korea. Its winter distribution is concentrated at ~20°N (Rice 1998). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001). It occurs 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).

Sei whales may have been sighted during surveys in the greater ETP (Wade and Gerrodette 1993; Kinzey et al. 1999, 2000, 2001; Ferguson and Barlow 2001); however, it is difficult to distinguish sei whales from Bryde's whales. Because sei whales generally have a more northerly and temperate distribution (Leatherwood et al. 1988), Wade and Gerrodette (1993) classified any tentative sei whale observations in the ETP as Bryde's whale sightings. Sei whales are known to occasionally occur in the Gulf of California (Urbán et al. 2014 *in* Heckel et al. 2020), as well as off the west coast of the Baja California Peninsula (Heckel et al. 2020). One sighting has been reported for waters off Nayarit (Urbán et al. 1997, Guerrero et al. 2006 *in* Heckel et al. 2020), and another sighting was made near the northern part of the proposed survey area, off Jalisco (Heckel et al. 2020). González et al. (2008) also reported the presence of sei whales off west coast of Mexico south of 23°N.

However, neither Ferguson and Barlow (2001) nor Jackson et al. (2004) positively identified any sei whales in Mexican waters during surveys conducted during July–December, although Jackson et al. (2004) reported a sighting of *B. borealis/edeni* near the northern part of the proposed survey area in 2003. Based on July–December 1986–1996 surveys, the density of Bryde's/sei whales in the proposed project area was zero but ranged to 0.0005/km^2 in adjacent waters (Ferguson and Barlow 2001). Four sightings of single Bryde's/sei whales were made during surveys off the coast of Mexico during November 2019 (Oedekoven et al. 2021). RPS (2022) reported two sightings of single sei whales during an L-DEO survey off Guerrero and Michoacán in May–June 2022. There are no sightings in the OBIS database for the waters in and adjacent to the proposed survey (OBIS 2024).

Fin Whale (*Balaenoptera physalus physalus*)

The fin whale is widely distributed in all the World's oceans (Gambell 1985), although it is most abundant in temperate and cold waters (Aguilar and García-Vernet 2018). Nonetheless, its overall range and distribution are not well known (Jefferson et al. 2015). A review of fin whale distribution in the North Pacific noted the lack of sightings across pelagic waters between eastern and western winter areas (Mizroch et al. 2009). Fin whales most commonly occur offshore, but can also be found in coastal areas (Jefferson et al. 2015).

Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in summer (Aguilar and García-Vernet 2018). Some animals may remain at high latitudes in winter or low latitudes in summer (Edwards et al. 2015). The northern and southern fin whale populations likely do not interact owing to their alternate seasonal migration; the resulting genetic isolation has led to the recognition of two subspecies, *B. physalus quoyi* and *B. p. physalus* in the Southern and Northern hemispheres, respectively (Anguilar and García-Vernet 2018). The fin whale is known to use the shelf edge as a migration route (Evans 1987). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily, or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex (Jefferson et al. 2015). Stafford et al. (2009) noted that sea-surface temperature is a good predictor variable for fin whale call detections in the North Pacific.

North Pacific fin whales summer from the Chukchi Sea to California and winter from California southwards (Gambell 1985). Information about the seasonal distribution of fin whales in the North Pacific has been obtained from the detection of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2007, 2009). Fin whale calls are recorded in the North Pacific year-round (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015). However, fin whales are considered rare in the proposed survey area.

Although Gerrodette and Palacios (1996) reported an abundance of 145 fin whales for the EEZ of Pacific Mexico, this abundance is based on sightings off the west coast of the Baja California Peninsula (see Ferguson and Barlow 2001). No sightings were made in the proposed survey area during July–December surveys during 1986–1996, 2003, or 2019 (Ferguson and Barlow 2001; Jackson et al. 2004; Oedekoven et al. 2021). Similarly, Edwards et al. (2015) reported no sightings or acoustic detections for the proposed survey area, although sightings have been reported for the Gulf of California and a few sightings exist for offshore waters far west of Mexico. However, González et al. (2008) reported the presence of this species off west coast of Mexico south of 23°N, and a sighting has been reported for Banderas Bay (Arroyo 2017). RPS (2022) reported one fin whale sighting during an L-DEO survey off Guerrero and Michoacán in May–June 2022. There are no sightings in the OBIS database for the waters in and adjacent to the proposed survey, but there are two records for the far offshore waters of Mexico; the sightings were made between 15.8°–21.0°N and 116.1°–119.6°W during November and December (OBIS 2024).

Blue Whale (*Balaenoptera musculus*)

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). 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). Blue whales are most often found in cool, productive waters where upwelling occurs (Reilly and Thayer 1990). 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: the eastern and central (formerly western) stocks (Carretta et al. 2021). The status of these two populations could differ substantially, as little is known about the population size in the western North Pacific (Branch et al. 2016). Blue whales from the eastern stock winter in Mexico and Central America (Stafford et al. 1999, 2001) and feed off the U.S. West Coast, as well as the Gulf of Alaska, during summer (Sears and Perrin 2018; Carretta et al. 2021). However, Busquets-Vass et al. (2021) suggested that most blue whales from the North Pacific feed in the California Current System, whereas some individuals occur in the Gulf of California or CRD for most of the year. The central North Pacific stock feeds off Kamchatka, south of the Aleutians and in the Gulf of Alaska during summer (Stafford 2003; Watkins et al. 2000b) and migrates to the western and central Pacific (including Hawaii) to breed in winter (Stafford et al. 2001; Carretta et al. 2021).

In the Northeast Pacific Ocean, including the ETP, blue whale calls are detected year-round (Stafford et al. 1999, 2001, 2009; Monnahan et al. 2014). Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections. In the ETP, blue whales have been sighted mainly off the Baja California Peninsula, near Costa Rica particularly the CRD, at and near the Galápagos Islands, and along the coasts of Ecuador and northern Peru (Clarke 1980; Donovan 1984; Reilly and Thayer 1990; Mate et al. 1999; Palacios 1999; Palacios et al. 2005; Branch et al. 2006). However, sightings have also been made off the mainland coast of Mexico (Fiedler 2002), including Banderas Bay (Arroyo 2017). In Mexican waters, blue whales generally occur from December–April (Rice 1974; Yochem and Leatherwood 1985; Gendron 2002 *in* Heckel et al. 2020), after which time they migrate northward; a large proportion occurs off California during the summer (Sears and Perrin 2018).

During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 30 sightings of blue whales were made (Gerrodette and Palacios 1996). Based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 773 blue whales for the EEZ of Pacific Mexico. Based on surveys in 1997 and 1998, Gendron (2002 *in* Heckel et al. 2020) estimated the abundance off the western coast of the Baja California Peninsula at 576 individuals. The density of blue whales in the proposed project area was zero based on July–December surveys during 1986–1996 (Ferguson and Barlow 2001). Sightings were made in and near the proposed survey area during surveys in 1998–2000 (Forney et al. 2012). One sighting was made near the proposed survey area during July–December surveys in 2003; additional sightings were made off the west coast of Baja California Peninsula (Jackson et al. 2004). Two sightings each of two blue whales were made during surveys off the Pacific coast of Mexico during November 2019 (Oedekoven et al. 2021). There are ~60 sightings of blue whales in the OBIS database for the waters in and adjacent to the proposed survey; sightings were made during November, December, March, and May (OBIS 2024). Blue whales are likely to be uncommon to rare in the proposed survey area during late spring.

Odontocetes

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is widely distributed, occurring from the edge of the polar pack ice to the Equator in both hemispheres, with the sexes occupying different distributions (Whitehead 2018). In general, it is distributed over large temperate and tropical areas that have high secondary productivity and steep underwater topography, such as volcanic islands (Jaquet and Whitehead 1996). Its distribution and relative abundance can vary in response to prey availability, most notably squid (Jaquet and Gendron 2002). Females generally inhabit waters >1000 m deep at latitudes <40º where sea surface temperatures are <15ºC; adult males move to higher latitudes as they grow older and larger in size, returning to warm-water breeding grounds (Whitehead 2018).

Sperm whales are distributed widely across the North Pacific (Rice 1989). Males migrate north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988). During summer and fall, sperm whales are widely distributed in the ETP, although they are generally more abundant in deep "nearshore" waters than far offshore (e.g., Polacheck 1987; Wade and Gerrodette 1993). It is not clear whether sperm whales seen in the ETP are part of the Northern or Southern Hemisphere stocks, or whether they should be considered a separate stock (Berzin 1978). More than 180 sightings have been reported for the ETP, with the highest concentrations at 10°N–10°S, 80°–100°W (Guerrero et al. 2006).

Sightings for Pacific Mexico include records off the Baja California Peninsula and in the Gulf of California (Guerrero et al. 2006; Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 46 sightings of sperm whales were made (Gerrodette and Palacios 1996). Based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 2810 sperm whales for the Pacific EEZ of Mexico, excluding the Gulf of California. In the proposed study area, the sperm whale density was zero, but adjacent areas had densities up to 0.003/km^2 according to surveys conducted in July–December 1986–1996 (Ferguson and Barlow 2001). No sightings were made along the mainland coast of Mexico during July–December surveys in 2003, although one sighting was made off the west coast of Baja California Sur (Jackson et al. 2004). Records also exist for Banderas Bay (Arroyo 2017) and Oaxaca (Pérez and Gordillo 2002 *in* Heckel et al. 2020). There are 22 non-whaling records in the OBIS database for the waters in and adjacent to the proposed survey area; all sightings were made from August through November (OBIS 2024).

Pygmy and Dwarf Sperm Whales (*Kogia breviceps and K. sima*)

The pygmy and dwarf sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2018). It has 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 ETP (Wade and Gerrodette 1993). 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; Jefferson et al. 2015). However, McAlpine (2018) noted that dwarf sperm whales may be more pelagic than pygmy sperm whales. *Kogia* spp. are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). Although there are few useful estimates of abundance for pygmy or dwarf sperm whales anywhere in their range, they are thought to be fairly common in some areas.

Vocalizations of *Kogia* spp. have been recorded in the North Pacific Ocean (Merkens et al. 2016). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, eight sightings of pygmy sperm whales were made (Gerrodette and Palacios 1996). Pygmy sperm whale strandings have been reported for the Gulf of California (Guerrero et al. 2006; Heckel et al. 2020) and Banderas Bay (Arroyo 2017), and sightings of pygmy sperm whales have been made just north of the proposed survey area off Jalisco (Salinas 2005, Godinez et al. 2015 *in* Heckel et al. 2020). According to Heckel et al. (2020), pygmy sperm whale distribution in Mexico does not extend farther south than Jalisco.

Dwarf sperm whales are known to occur along most of the Mexican coast; in the Gulf of California, they occur year-round (Urbán et al. 2012 *in* Heckel et al. 2020). They also occur off the west coast of the Baja California Peninsula, and there appears to be a resident population in Banderas Bay (Arroyo 2017). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 29 sightings of dwarf sperm whales were made (Gerrodette and Palacios 1996). The density of dwarf sperm whales in the proposed study area was 0.0171/km^2 during July–December 1986–1996, but ranged up to 0.021/ km^2 in adjacent waters (Ferguson and Barlow 2001). Dwarf sperm whales were seen in the proposed survey area during 1998–2000 (Forney et al. 2012). Several sightings of dwarf sperm whales were made along the mainland coast of Mexico during July–December surveys in 2003, including within the proposed survey area (Jackson et al. 2004). Three sightings of single dwarf sperm whales were made during surveys off the coast of Mexico during November 2019 (Oedekoven et al. 2021). There are over 100 sightings of dwarf sperm whales in the OBIS database for the waters in and adjacent to the proposed survey; sightings were made from August through November; there are no confirmed sightings of pygmy sperm whales (OBIS 2024).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread and common of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989; Baird 2018a). It is rarely observed at sea and is known mostly from strandings; it strands more commonly than any other beaked whale (Heyning 1989). Cuvier's beaked whale is found in deep water in the open ocean and over and near the continental slope (Gannier and Epinat 2008; Baird 2018a). Ferguson et al. (2006) noted that in the ETP, the mean water depth where Cuvier's beaked whales were sighted was ~3.4 km. Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels all help to explain the infrequent sightings (Barlow and Gisiner 2006).

Cuvier's beaked whales are widely distributed in the ETP, and MacLeod and Mitchell (2006) identified this region as a key area for beaked whales. Ferguson et al. (2006) reported 90 sightings in the ETP. There are numerous records for the Gulf of California and off the Baja California Peninsula (Heckel et al. 2020), and it also occurs in Banderas Bay (Arroyo 2017). The Guadalupe Islands appear to be an important area for this species, possibly for breeding and foraging (Cárdenas-Hinojosa et al. 2015 *in* Heckel et al. 2020), as numerous sightings have been made there, including 33 sightings of one to six individuals in 2016 (Cárdenas-Hinojosa et al. 2017 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Pacific during July–December 1986–1990, 1992 and 1993, 18 sightings of Cuvier's beaked whales were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 68,828 ziphiids for the EEZ of Pacific Mexico. During surveys conducted during July–December 1986–1996, density of Cuvier's beaked whales within the proposed study area was 0.0025/km^2, but ranged up to 0.0035/km^2 in adjacent waters (Ferguson and Barlow 2001). Sightings were also made in the proposed survey area during 1998 surveys (Forney et al. 2012). In addition, several sightings were made along the mainland coast of Mexico during July–December surveys in 2003, including within the proposed survey area (Jackson et al. 2004). One sighting of two Cuvier's beaked whales was reported during surveys off the Pacific coast of Mexico during November 2019 (Oedekoven et al. 2021). There are ~70 sightings of Cuvier's beaked whales in the OBIS database for the waters in and adjacent to the proposed survey; sightings were made from August through November (OBIS 2024).

Longman's Beaked Whale (*Indopacetus pacificus*)

Longman's beaked whale, also known Indo-Pacific beaked whale or tropical bottlenose whale, occurs in tropical waters throughout the Indo-Pacific (Pitman 2018a). Longman's beaked whale is most often sighted in waters with temperatures ≥21°C and over or adjacent to continental slopes (Anderson et al. 2006; Jefferson et al. 2015). Longman's beaked whale is rare in the eastern Pacific (Pitman 2018a; Heckel et al. 2020). In the ETP, most tropical bottlenose whale sightings have been made between 3°N and 10°N (Pitman et al. 1999). Kinzey et al. (2001) noted one sighting of *I. pacificus* in the ETP at ~6.9°N, 135.5°W. Pitman et al. (1999) suggested that several sightings of *Hyperoodon* spp. in the ETP were actually misidentifications (e.g., Wade and Gerrodette 1993) and were, in fact, sightings of tropical bottlenose whales.

Both Ferguson and Barlow (2001) and Jackson et al. (2004) reported *I. pacificus* in the ETP. However, the density of tropical bottlenose whales in the proposed project area was zero based on 10 years of surveys during July–December (Ferguson and Barlow 2001). There are, however, other records for the Mexican Pacific as well as the Gulf of California (Rosales-Nanduca et al. 2011, Arellano-Peralta and Medrano-González 2015, Urbán et al. 2012 *in* Heckel et al. 2020). There is one sighting in the OBIS database for the proposed survey area; the sighting was made during September 1987 at 14.7°N, 101.6°W (OBIS 2024).

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans; it has the widest distribution throughout the world of any *Mesoplodon* species (Pitman 2018b). Occasional occurrences in cooler, higher-latitude waters are presumably related to warm-water incursions (Reeves et al. 2002). Like other beaked whales, Blainville's beaked whale is generally found in waters 200–1400 m deep (Gannier 2000; Jefferson et al. 2015). In the ETP, Blainville's beaked whales have been sighted in offshore as well as nearshore areas of Central and South America (Pitman et al. 1987; Ferguson and Barlow 2001; Pitman and Lynn 2001). MacLeod et al. (2005) reported stranding and sighting records in the eastern Pacific ranging from 37.3°N to 41.5°S. MacLeod and Mitchell (2006) identified the ETP as a key area for beaked whales.

There have been very few sightings off the west coast of Mexico (Heckel et al. 2020), but sightings have been reported off the Baja California Peninsula, an unconfirmed sighting was made in the Gulf of California, and there were sightings in Banderas Bay (Esquivel et al. 1993 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, one sighting of Blaineville's beaked whale was made

(Gerrodette and Palacios 1996). However, no sightings were made within the proposed survey area during July–December 1986–1996 surveys (Ferguson and Barlow 2001). There are no sightings in the OBIS database for the waters in and adjacent to the proposed survey (OBIS 2024).

Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

The ginkgo-toothed beaked whale is only known from stranding and capture records (Mead 1989; Jefferson et al. 2015). It is hypothesized to occupy tropical and warm temperate waters of the Indian and Pacific oceans (Pitman 2018b). Its distributional range in the North Pacific extends from Japan to the Galapagos Islands, and there are also records for the South Pacific as far south as Australia and New Zealand (Jefferson et al. 2015). The species is thought to occupy relatively cool areas in the temperate and tropical Pacific, where upwelling is known to occur, such as in the California and Peru currents and the equatorial front (Palacios 1996). For Mexico, there is a single record for the west coast of the Baja California Peninsula, and a skull was found in the Gulf of California (Heckel et al. 2020). The density of unidentified *Mesoplodon* sp. in the proposed study area was 0.0028/km^2 (Ferguson and Barlow 2001); some of these sightings could have potentially been gingko-toothed beaked whales. There are no records for ginkgo-toothed beaked whales in the OBIS database for Mexican waters (OBIS 2024).

Deraniyagala's Beaked Whale (*Mesoplodon hotaula*)

Deraniyagala's beaked whale is a newly recognized species of whale that recently has been described for the tropical Indo-Pacific, where it is thought to occur between ~15°N and ~10°S (Dalebout et al. 2014). Strandings have been reported for the Maldives, Sri Lanka, Seychelles, Kiribati, and Palmyra Atoll (Dalebout et al. 2014), and acoustic detections have been made at Palmyra Atoll and Kingman Reef in the Line Islands (Baumann-Pickering et al. 2014). It is closely related to ginkgo-toothed beaked whale, but DNA and morphological data have shown that the two are separate species (Dalebout et al. 2014). It is possible that this species may occur off the coast of Mexico. There are no sightings in the OBIS database for Mexican waters (OBIS 2024).

Pygmy Beaked Whale (*Mesoplodon peruvianus*)

The pygmy beaked whale is the smallest mesoplodont (Reyes 1991). This eastern-Pacific species is thought to occur between 25°N and 15°S, from the Baja California Peninsula to Peru, foraging in mid-to-deep waters (Urbán-Ramírez and Aurioles-Gamboa 1992). However, Pitman and Lynn (2001) noted a stranding record for the species in Chile, at 29.25°S. Pitman and Lynn (2001) noted that the species may have been known previously as *M*. sp. "A". The pygmy beaked whale is believed to be widespread in the ETP and is the most frequently sighted *Mesoplodon* sp. there (Pitman 2018b); it appears to be concentrated off central Mexico (Pitman and Lynn 2001). Wade and Gerrodette (1993) reported several sightings for *M. peruvianus* as well as *M.* sp. "A" in the ETP.

During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 13 sightings of *Mesoplodon* sp. A were made (Gerrodette and Palacios 1996). Densities of *Mesoplodon* sp. A based on July–December 1986–1996 surveys were zero for the proposed survey area (Ferguson and Barlow 2001). There are several sighting and stranding records for the pygmy beaked whale for the Pacific coast of Mexico, including records for Banderas Bay and Oaxaca (Heckel et al. 2020). No sightings of pygmy beaked whales were made off Mexico during July–December surveys in 2003; however, several sightings of *Mesoplodon* sp. A were made off the mainland coast of Mexico, including near the proposed survey area (Jackson et al. 2004). Two sightings of pygmy beaked whales were made off Central America during July–December surveys in 2003 (Jackson et al. 2004). Three sightings of pygmy beaked whale were reported during surveys off the coast of Mexico during November 2019 (Oedekoven et al. 2021); the mean group size was three. There are 27 sightings in the OBIS database for the proposed survey area; sightings were made from September through December (OBIS 2024).

Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is distributed worldwide in mid-temperate and tropical oceans (Kruse et al. 1999). although it shows a preference for mid-temperate waters of the shelf and slope between 30° and 45° (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).

Polacheck (1987) noted that the highest encounter rates of Risso's dolphin in the ETP were in (relatively) nearshore areas. Risso's dolphins occur along the entire Pacific coast of Mexico (Heckel et al. 2020), including Banderas Bay (Arroyo 2017). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 73 sightings of Risso's dolphins were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 24,084 Risso's dolphins for the Pacific EEZ of Mexico. Sightings of Risso's dolphins were made in and near the survey area during surveys in 1998–2000 (Forney et al. 2012) and between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). One sighting of 33 Risso's dolphins was made during surveys off the coast of Mexico during November 2019 (Oedekoven et al. 2021). The density of Risso's dolphin in the project area was reported as 0.0761/km^2 by Ferguson and Barlow (2001). There are over 100 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; the sightings were made from September through December (OBIS 2024).

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is distributed worldwide in tropical to warm temperate oceanic waters (Miyazaki and Perrin 1994). In the Pacific, it occurs from central Japan and northern Australia to the Baja California Peninsula, Mexico, and southern Peru (Jefferson et al. 2015). It generally occurs in deep, oceanic waters, but can be found in shallower coastal waters in some regions (Jefferson et al. 2015). In the ETP, sightings of rough-toothed dolphins have been reported by Perrin and Walker (1975), Pitman and Ballance (1992), Wade and Gerrodette (1993), Kinzey et al. (1999, 2000, 2001), Ferguson and Barlow (2001), Jackson et al. (2004), and May-Collado et al. (2005). In Mexico, rough-toothed dolphins occur from the southern Baja California Peninsula and the Gulf of California, southward along the entire coast (Urbán 2008 *in* Heckel et al. 2020). This species is common although not abundant in Banderas Bay (Arroyo et al. 2016) and may be resident off Oaxaca (Ramírez-Barragán et al. 2014 *in* Heckel et al. 2020).

Gerrodette and Palacios (1996) reported an abundance of 37,511 rough-toothed dolphins for the EEZ of Pacific Mexico, excluding the Gulf of California, based on surveys during July–December 1986–1990, 1992 and 1993. The density of rough-toothed dolphin encompassing the proposed project area was 0.0226/km^2 but ranged up to 0.0362/km^2 in adjacent water, based on surveys conducted during July–December 1986–1996 (Ferguson and Barlow 2001). Sightings of rough-toothed dolphins were made in and near the proposed survey area during surveys conducted in 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). Ten sightings were made during surveys off the Pacific coast of Mexico during November 2019; the mean group size was seven (Oedekoven et al. 2021). There are over 200 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; sightings were made from September through November (OBIS 2024).

Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2018). In the ETP, bottlenose dolphins tend to be more abundant close to the coasts and islands (Scott and Chivers 1990); they also seem to occur more inshore than other dolphin species (Wade and Gerrodette 1993).

Common bottlenose dolphins occur in all Pacific waters of Mexico (Urbán 2008 *in* Heckel et al. 2020), including Banderas Bay, Nayarit, and off Oaxaca (Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 163 sightings of bottlenose dolphins were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 61,536 bottlenose dolphins for the Pacific EEZ of Pacific. The density of bottlenose dolphin in the project area was 0.0373/km^2 based on surveys conducted during July–December 1986–1996 (Ferguson and Barlow 2001). Sightings of bottlenose dolphins were made in and near the proposed survey area during surveys in 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). Ten sightings were reported during surveys off the Pacific coast of Mexico during November 2019; the mean group size was eight (Oedekoven et al. 2021). Acoustic detections were reported to the northwest and southeast of the proposed survey area during summer/fall of 1998 and 1999 (Oswald et al. 2003). There are over 200 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; sightings were made from September through December (OBIS 2024).

Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin is one of the most abundant cetaceans and is distributed worldwide in tropical and some subtropical waters, between ~40°N and 40°S (Jefferson et al. 2015). In the ETP, this species ranges from 25ºN off the Baja California Peninsula to 17ºS, off southern Peru (Perrin and Hohn 1994). Au and Perryman (1985) noted that the pantropical spotted dolphin occurs primarily north of the Equator, off southern Mexico, and westward along 10ºN. There are two forms of pantropical spotted dolphin (Perrin 2018a): coastal (*S. a. graffmani*) and offshore (*S. a. attenuata*), both of which could occur within the proposed survey area. Along the coast of Latin America, the coastal form typically occurs within 20 km from shore (Urbán 2008 *in* Heckel et al. 2020). There are currently three recognized stocks of spotted dolphins in the ETP: the coastal stock and two offshore stocks – the northeast and the west/south stocks (Wade and Gerrodette 1993; Leslie et al. 2019). However, based on more recent data, there are at least nine genetically distinct stocks of this species in coastal areas from the Baja California Peninsula south to Ecuador (Rosales and Escorza-Treviño 2005; Escorza-Treviño et al. 2005).

Much of what is known about the pantropical spotted dolphin in the ETP is related to the tuna purse-seine fishery in that area (Perrin and Hohn 1994). There was an overall stock decline of spotted dolphins from 1960–1980 because of the fishery (Allen 1985). In 1979, the population size of spotted dolphins in the ETP was estimated at 2.9–3.3 million (Allen 1985). For 1986–1990, Wade and Gerrodette (1993) reported an estimate of 2.1 million. Gerrodette and Forcada (2005) noted that the population of offshore northeastern spotted dolphins had not yet recovered from the earlier population declines; possible reasons for the lack of growth were attributed to unreported bycatch, effects of fishing activity on survival and reproduction, and long-term changes in the ecosystem. The abundance estimate for 2006 was ~857,884 northeastern offshore spotted dolphins, and 439,208 western-southern offshore spotted dolphins; the coastal subspecies was estimated at 278,155 and was less affected by fishing activities (Gerrodette et al. 2008). In 2004, the mortality rate in the tuna fishery was estimated at 0.03% (Bayliff 2004). Perrin (2018a) noted that for the last few years, hundreds of spotted dolphins have been taken in the fishery. Currently, there are ~640,000 northeastern offshore spotted dolphins inhabiting the ETP (Perrin 2018a). This stock is still considered depleted and may be slow to recover due to continued chase and encirclement by the tuna fishery, which may in turn affect reproductive rates (Cramer et al. 2008; Kellar et al. 2013).

The spotted dolphin is widely distributed in Mexican waters (Heckel et al. 2020) and is expected to be the most common delphinid in the area. Approximately 500 coastal spotted dolphins inhabit the waters off Colima and southern Jalisco, but only 3% are considered resident, so the area appears to be used for transit (González-Salguero et al. 2016 *in* Heckel et al. 2020). The Pantropical spotted dolphin is resident off Oaxaca and the most abundant marine mammal in the region (Pérez and Gordillo 2002 *in* Heckel et al. 2020). It is also the most common species in Banderas Bay (Arroyo 2017). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 251 sightings of offshore and eight sightings of coastal spotted dolphins were made (Gerrodette and Palacios 1996). Based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 146,296 spotted dolphins for the Pacific EEZ of Mexico. Densities of spotted dolphins in the region encompassing the proposed project area ranged from zero for the coastal stock to 0.0068/km^2 for the offshore stock; densities for the offshore stock ranged up to 0.026564/km^2 in waters adjacent to the proposed survey area (Ferguson and Barlow 2001). Sightings of spotted dolphins were made in and near the proposed survey area during surveys in 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). Twenty-six sightings of offshore spotted dolphins were made during surveys off the coast of Mexico during November 2019, with a mean group size was 30; three sightings of the coastal form were also made, with a mean group size of 21 (Oedekoven et al. 2021). In addition, 32 sightings of unspecified *S. attenuata* were made off the coast of Mexico during those surveys, for which the group size was 26 (Oedekoven et al. 2021). Two sightings totaling 13 individuals were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). There are nearly 1000 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; sightings were made from September through November (OBIS 2024).

Spinner Dolphin (*Stenella longirostris*)

The spinner dolphin is pantropical in distribution, including oceanic tropical and sub-tropical waters between 40ºN and 40ºS (Jefferson et al. 2015). It is generally considered a pelagic species, but it can also be found in coastal waters (Perrin 2018b). In the Pacific, Au and Perryman (1985) noted that the spinner dolphin occurs primarily north of the Equator, off southern Mexico, and westward along 10ºN; they also noted its occurrence in seasonal tropical waters south of the Galápagos Islands. In the ETP, three types of spinner dolphins have been identified and two of those are recognized as subspecies: the eastern spinner dolphin (*S.l.* orientalis), considered an offshore species, the Central American spinner (*S.l. centroamericana*; also known as the Costa Rican spinner), considered a coastal species occurring from southern Mexico to Costa Rica (Perrin 1990; Dizon et al. 1991), and the 'whitebelly' spinner is thought to be a hybrid of the eastern spinner and Gray's spinner (*S.l. longirostris*). Gray's spinner dolphin is not expected to occur within the proposed study area. The whitebelly spinner dolphin is common in oceanic waters of the ETP (Heckel et al. 2020).

Although there is a great deal of overlap between the ranges of eastern and whitebelly spinner dolphins, the eastern form generally occurs in the northeastern portion of the ETP, whereas the whitebelly spinner occurs in the southern portion of the ETP, ranging farther offshore (Wade and Gerrodette 1993; Reilly and Fiedler 1994). Reilly and Fiedler (1994) noted that eastern spinners are associated with waters that have high surface temperatures and chlorophyll and shallow thermoclines, whereas whitebelly spinners are associated with cooler surface temperatures, lower chlorophyll levels, and deeper thermoclines. The eastern spinner dolphins are the most likely to occur in the proposed survey area (see Ferguson and Barlow 2001; Heckel et al. 2020), as this subspecies occurs in the ETP, east of 145°W, between 24°N off the Baja California Peninsula and 10°S off Peru (Perrin 1990).

Wade and Gerrodette (1993) reported an abundance estimate of 1.7 million, and Gerrodette et al. (2005) estimated the abundance at 1.1 million for 2003. Gerrodette and Forcada (2005) noted that the population of eastern spinner dolphins had not yet recovered from the earlier population declines due to the tuna fishery. The population estimate for eastern spinner dolphins in 2003 was 612,662 (Gerrodette et al. 2005). In 2000, the whitebelly dolphin was estimated to number 801,000 in the ETP (Gerrodette et al. 2005). Bayliff (2004) noted a spinner dolphin mortality rate in the tuna fishery of 0.03% for 2004. Possible reasons why the population has not recovered include under-reported bycatch, effects of fishing activity on survival and reproduction, and long-term changes in the ecosystem (Gerrodette and Forcada 2005). The continued chase and encirclement by the tuna fishery may be affecting the reproductive rates of the eastern spinner dolphin (Cramer et al. 2008).

The spinner dolphin is expected to be one of the most abundant cetacean species in the project area. Sightings have also been made in Nayarit, including Banderas Bay (Arroyo 2017) and off Oaxaca (Meraz and Sánchez-Díaz 2008; Pérez and Gordillo 2002 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 163 sightings of eastern spinner dolphin were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 186,906 spinner dolphins for the Pacific EEZ of Pacific. Data from Ferguson and Barlow (2001) showed that the density of eastern spinner dolphin was 0.2775/km^2 in the proposed survey area; the whitebelly spinner dolphin had densities of zero. Sightings of eastern spinner dolphins were made in and near the proposed survey area 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). One hundred eight sightings of eastern spinner dolphins were made during surveys off the coast of Mexico during November 2019; the mean group size was 140 (Oedekoven et al. 2021). Ten sightings totaling 293 spinner dolphins were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). Acoustic detections were reported to the northwest and southeast of the proposed survey area during summer/fall of 1998 and 1999 (Oswald et al. 2003). There are over 500 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; sightings were made from September through December (OBIS 2024).

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994a; Jefferson et al. 2015). It is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling; however, it has also been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015). It is common in the ETP up to 25°N (Perrin et al. 1985). In the ETP, striped dolphin distribution is associated with cool, upwelling areas along the equator (Au and Perryman 1985).

In Mexico, striped dolphins occur from the Baja California Peninsula along the entire coast, but they do not occur in the northern Gulf of California (Perez-Cortés et al. 2000). The striped dolphin is expected to be one of the most abundant cetaceans in the offshore waters of the proposed project area, but has been reported in Banderas Bay and off Matanchén Beach, San Blas, Nayarit (Videl et al. 1993, Urbán 2008 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 160 sightings of striped dolphins were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 128,867 striped dolphins for the Pacific EEZ of Pacific Mexico. Polacheck (1987) noted that the highest encounter rates in the ETP were off western Mexico. Ferguson and Barlow (2001) reported a density of 0.016/km^2 for striped dolphin in the survey area, and densities u to 0.1687/km^2 in adjacent waters. Sightings of striped dolphins were made in and near the proposed survey area during survey in 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). Two sightings totaling six individuals were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). There are nearly 200 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; sightings were made from September through December (OBIS 2024).

Common Dolphin (*Delphinus delphis*)

The common dolphin is found in oceanic and nearshore waters of tropical and warm temperate oceans around the world, ranging from ~60ºN to ~50ºS (Jefferson et al. 2015). Based on Perrin (2018c), here we assume that there are currently three recognized subspecies of common dolphin, including *D. delphis delphis* (the short-beaked form), *D. delphis bairdii* (the long-beaked form, formerly known as *D. capensis*), and *D. delphis tropicalis* (Indian Ocean subspecies). However, Jefferson et al. (2024) consider the long-beaked form that occurs in the ETP as a separate species (*D. bairdii*), but the long-beaked form is generally not known to occur off mainland Mexico (Urbán 2008). The long-beaked form generally prefers shallower water (Perrin 2018c), typically occurring within 180 km from shore (Jefferson et al. 2015). The common dolphin is very abundant in the ETP (Perrin 2018c), and its distribution there is associated with cool, upwelling areas along the Equator and off the Baja California Peninsula, Central America, and Peru (Au and Perryman 1985; Reilly 1990; Reilly and Fiedler 1994; Ballance et al. 2006). Reilly (1990) noted no seasonal changes in common dolphin distribution, although Reilly and Fiedler (1994) observed interannual changes in distribution that were likely attributable to El Niño events.

The short-beaked form occurs along the entire coast of Mexico and has been sighted near the proposed survey area off Nayarit, Michoacán, and Guerrero; the long-beaked form occurs off the Baja California Peninsula and the Gulf of California (Heckel et al. 2020). The southern limit of the long-beaked form appears in Mexico appears to be 22°N (Urbán 2008); no sightings in Mexican waters have been made south of that. Thus, only the short-beaked form is expected to occur within the study area. During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 92 sightings of short-beaked and 74 sightings of long-beaked common dolphins were made. Gerrodette and Palacios (1996) reported an abundance of 283,196 short-beaked common dolphins and 55,112 long-beaked common dolphins for the Pacific EEZ of Mexico. The density of short-beaked common dolphin in the proposed survey area was 0.02375/km^2 based on July–December 1986–1996 surveys, but ranged up to 0.0486/km^2 in adjacent waters; the density for long-beaked common dolphins was zero (Ferguson and Barlow 2001). Several sightings of short-beaked common dolphins were made along the mainland coast of Mexico during July–December surveys in 2003, including within the proposed survey area; sightings of the long-beaked form were made off the Baja California Peninsula (Jackson et al. 2004). Sightings of common dolphins were also made in coastal waters of the proposed survey area during surveys in 1998–2000 and 2006 (Gerrodette et al. 2008; Forney et al. 2012) and during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007

(Schwarz et al. 2010). Nine sightings were made during surveys off the coast of Mexico during November 2019; the mean group size was 126 dolphins (Oedekoven et al. 2021). Four sightings totaling 117 common dolphins were made during an L-DEO survey off Guerrero and Michoacán in May–June 2022 (RPS 2022). There are ~70 sightings of short-beaked common dolphins in the OBIS database for the waters in and adjacent to the proposed survey area, with sightings from September through November; there are no records for the long-beaked form (OBIS 2024).

Fraser's Dolphin (*Lagenodelphis hosei*)

Fraser's dolphin is a tropical oceanic species distributed between 30°N and 30°S that generally inhabits deep oceanic water (Dolar 2018). It occurs rarely in temperate regions and then only in relation to temporary oceanographic anomalies such as El Niño events (Perrin et al. 1994b). The species occurs throughout the ETP (Perrin et al. 1973, 1994b) and has been sighted there at least 15 km from shore in waters 1500–2500 m deep (Dolar 2018). Wade and Gerrodette (1993) showed a mainly equatorial distribution in the ETP and estimated its abundance in the area at 289,300 individuals. Pitman and Ballance (1992) also noted its occurrence in the ETP. Pérez-Cortés et al. (2000) reported sightings off northwestern Mexico, and two sightings have been reported near the Revillagigedo Archipelago (Heckel et al. 2020). González et al. (2008) also reported the presence of Fraser's dolphin off the west coast of Mexico between 18° and 23°N, as well as the possible presence south of 18°N. The density of Fraser's dolphin in the region encompassing the proposed project area was zero based on 1986–1996 surveys (Ferguson and Barlow 2001). There are no sightings for Pacific waters of Mexico in the OBIS database (OBIS 2024).

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is found in tropical and warm temperate waters (Olson 2018); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). Pilot whales are generally nomadic, but may be resident in certain locations, such as California and Hawaii (Olson 2018). Pilot whales occur on the shelf break, over the slope, and in areas with prominent topographic features (Olson 2018). Based on genetic data, Van Cise et al. (2016) suggested that two types of short-finned pilot whales occur in the Pacific – one in the western and central Pacific, and one in the Eastern Pacific; they hypothesized that prey distribution rather than sea surface temperature determine their latitudinal ranges.

Pilot whales have a wide distribution throughout the ETP, but are most abundant in colder waters where upwelling occurs (Wade and Gerrodette 1993). Polacheck (1987) noted that encounter rates for pilot whales in the ETP were highest inshore, and that offshore concentrations may also occur, but at lower densities (Polacheck 1987). In Pacific waters of Mexico, sightings and strandings have been reported for the Gulf of California and off the west coast of the Baja California Peninsula, but Heckel et al. (2020) did not report any records in the Pacific waters off Mexico south of 20°N. However, González et al. (2008) reported the presence of this species off the entire west coast of Mexico.

The density encompassing the proposed project area was zero based on 1986–1996 surveys, but ranged up to 0.0015/km^2 in adjacent waters (Ferguson and Barlow 2001). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 15 sightings of short-finned pilot whales were made; based on those surveys, Gerrodette and Palacios (1996) reported an abundance of 3348 short-finned pilot whales for the Pacific EEZ of Mexico. No sightings were made along the mainland coast of Mexico during July–December surveys in 1998–2000, 2003, or 2006 (Jackson et al. 2004; Gerrodette et al. 2008; Forney et al. 2012). There are no sightings in the OBIS database for the waters in and adjacent to the proposed survey area, although there are sightings farther offshore (OBIS 2024).

Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world (Ford 2018). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). Killer whales tend to be more common in nearshore areas and at higher latitudes (Jefferson et al. 2015). Nonetheless, they can be found throughout the ETP (Pitman and Ballance 1992; Wade and Gerrodette 1993), but are most densely distributed near the coast from 35ºN to 5ºS (Dahlheim et al. 1982). Dahlheim et al. (1982) noted the occurrence of a cluster of sightings at two offshore locations in the ETP. One location was bounded by 7–14ºN and 127–139ºW, and the other was within a band between the equator and 5ºN and from the Galápagos Islands to 115ºW.

In Mexico, killer whales are most often reported off the west coast of the Baja California Peninsula, Revillagigedo Archipelago, and the Gulf of California (Guerrero 2013 *in* Heckel et al. 2020). Sightings have also been made in Banderas Bay (Arroyo 2017), and off Jalisco, Colima, Michoacán (Vargas-Bravo et al. 2014 *in* Heckel et al. 2020), and off Oaxaca (Meraz and Sánchez-Díaz 2008; Pérez and Gordillo 2002, Ponce-Quezada et al. 2014 *in* Heckel et al. 2020). In the Pacific waters of Mexico, killer whales most often occur along the continental shelf edge and nearshore (Guerero 1997, Guerrero et al. 2005 *in* Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 15 sightings of killer whales were made (Gerrodette and Palacios 1996). The density of killer whale in the proposed project area based on 1986–1996 surveys was 0.0001/km^2, but ranged up to 0.0003/km^2 in adjacent waters (Ferguson and Barlow 2001). One sighting was made near the proposed survey area during July–December surveys in 2003; additional sightings were made off the Baja California Peninsula (Jackson et al. 2004). One sighting of 16 killer whales was made during surveys off the coast of Mexico during November 2019 (Oedekoven et al. 2021). There are ~20 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; the sightings were made from August through November (OBIS 2024).

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters, generally between 50ºN and 50ºS (Odell and McClune 1999). It is widely distributed, but rare to uncommon throughout its range (Baird 2018b). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow water (Jefferson et al. 2015). In the North Pacific, it occurs from Japan and southern California, southward and across the Pacific, including Hawaii.

Wade and Gerrodette (1993) noted the occurrence of false killer whales especially along the Equator. False killer whales in the ETP are usually seen far offshore (Wade and Gerrodette 1983). They are thought to occur along the entire Pacific coast of Mexico (Heckel et al. 2020), including Banderas Bay (Arroyo 2017) and off Nayarit, Jalisco, Colima, and Oaxaca (Castillo-Sánchez et al. 2014 *in* Heckel et al. 2020). Douglas et al. (2023) reported 24 sightings totaling 103 false killer whales in the Pacific waters of Mexico from 1991 to 2022. During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, three sightings of false killer whales were made (Gerrodette and Palacios 1996). The density of this species in the proposed project area based on 1986–1996 surveys was zero, although adjacent areas had densities up to 0.0025/km^2 (Ferguson and Barlow 2001). One sighting was made within the proposed survey area during July–December surveys in 2003 (Jackson et al. 2004). Five sightings were made during surveys off the coast of Mexico during November 2019; the mean group size was 19 (Oedekoven et al. 2021). There are ~20 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; the sightings were made from August through November (OBIS 2024).

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale has a worldwide distribution in tropical waters (Baird 2018c), generally not ranging south of 35°S (Jefferson et al. 2015). In the North Pacific, it occurs from Japan and to the Baja California Peninsula, southward and across the Pacific Ocean, including Hawaii. In warmer water, it is usually seen close to the coast (Wade and Gerrodette 1993), but it is also found in deep waters.

Pygmy killer whales are known to occur in the ETP (e.g., Van Waerebeek and Reyes 1988; Pitman and Ballance 1992; Wade and Gerrodette 1993; Gerrodette and Palacios 1996). The pygmy killer whale may occasionally occur in small numbers in the proposed project area; sightings and stranding records exist for the Baja California Peninsula, Gulf of California, and offshore waters off Mexico (Heckel et al. 2020). During 25,356 km of surveys (excluding the Gulf of California) within the EEZ of Pacific Mexico, during July–December 1986–1990, 1992 and 1993, 13 sightings of pygmy killer whales were made (Gerrodette and Palacios 1996). The density of this species in the proposed project area, based on 1986–1996 surveys, was 0.0124/km^2, but ranged up to 0.0154/km^2 in adjacent waters (Ferguson and Barlow 2001). Records have also been reported for Banderas Bay (Arroyo 2017) and Jalisco (Godínez-Domí and Franco-Gordo 2013 *in* Heckel et al. 2020). Sightings were also made during surveys between 12°–17°N and 104°–108°W, southwest of Manzanilla, from late August–November 2007 (Schwarz et al. 2010). Four sightings were reported during surveys off the coast of Mexico during November 2019; the mean group size was 42 (Oedekoven et al. 2021). There are nearly 50 sightings in the OBIS database for the waters in and adjacent to the proposed survey area; the sightings were made from August through November (OBIS 2024).

Melon-headed Whale (*Peponocephala electra*)

The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40°N to 35°S (Jefferson et al. 2015). It is commonly seen in mixed groups with other cetaceans (Jefferson and Barros 1997). It occurs most often in deep offshore waters and occasionally in nearshore areas where deep oceanic waters occur near the coast (Perryman and Danil 2018). In the North Pacific, it is distributed south of central Japan and southern California, as well as across the Pacific, including Hawaii.

Au and Perryman (1985) and Perryman et al. (1994) reported that the melon-headed whale occurs primarily in equatorial waters, although Wade and Gerrodette (1993) noted its occurrence in non-equatorial waters. The melon-headed whale likely occurs in small numbers in the proposed project area; there are only a few records for Pacific waters of Mexico, in the Gulf of California (Urbán 2008; Pérez-Cortés et al. 2000; Heckel et al. 2020). However, based on surveys conducted during 1986–1996, the density of this species in the proposed project area was zero (Ferguson and Barlow 2001). There are three sightings in the OBIS database to the west of the proposed survey area; the sightings were made during September and October between 11.3°–12.8°N and 102.9°–103.0°W from August through November (OBIS 2024).

Pinnipeds

Guadalupe Fur Seal (*Arctocephalus townsendi*)

During the summer breeding season, most Guadalupe fur seal adults occur at rookeries in Mexico (Carretta et al. 2021). Most breeding and births occur at Isla Guadalupe, off the west coast of Baja California Peninsula; a secondary rookery exists at Isla Benito del Este (Maravilla-Chavez and Lowry 1999; Aurioles-Gamboa et al. 2010). A few Guadalupe fur seals are known to occur at California sea lion rookeries in the Channel Islands, primarily at San Miguel Island (Carretta et al. 2021), but sightings have also been made at Santa Barbara, San Nicolas, and San Clemente islands (Stewart et al. 1987). Following the breeding season, adult males tend to move north to forage. Fur seals younger than two years old are more likely to travel to more northerly, offshore areas than older fur seals (Norris 2017 *in* DoN 2019).

Females have been observed feeding south of Guadalupe Island, making an average round trip of 2375 km (Ronald and Gots 2003).

While at sea, this species usually is solitary but typically gathers in the hundreds to thousands at breeding sites. Guadalupe fur seals prefer rocky habitat for breeding and hauling out. They generally haul out at the base of towering cliffs on shores characterized by solid rock and large lava blocks (Peterson et al. 1968), although they can also inhabit caves and recesses (Belcher and Lee 2002). In 2015–2021, 715 Guadalupe fur seals stranded on the coast of west coast of the U.S.; this was declared an unusual mortality event or UME (NOAA 2024b). Guadalupe fur seals are unlikely to be encountered during the proposed seismic survey, as they typically occur farther north. However, Heckel et al. (2020) reported occasional records for Guerrero and Oaxaca. There are no sightings in or near the proposed study area in the OBIS database (OBIS 2024).

California Sea Lion (*Zalophus californianus californianus*)

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; Meraz and Sánchez-Díaz 2008), where it is occasionally recorded. The California sea lion has been documented as far south as Costa Rica on several occasions (e.g., Acevedo-Gutierrez 1996; Rodríguez-Herrera et al. 2002). It typically occurs within 16 km from shore, in water <1000 m (King 1990). The California sea lion is considered as the subspecies *Z. c. californianus* (other subspecies are found on the Galápagos Islands and in Japan, although the latter is likely extinct).

California sea lion rookeries are located on islands located in southern California, the western Baja California Peninsula, and the Gulf of California (Carretta et al. 2021). A single stock is recognized in U.S. waters, but there are five genetically distinct geographic populations (1) Pacific Temperate (includes rookeries in U.S. waters and the Coronados Islands to the south), (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California (Schramm et al. 2009). In California and the Baja California Peninsula, 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. 1992; 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).

During 25,356 km of surveys (excluding the Gulf of California) within the Pacific EEZ of Mexico, during July–December 1986–1990, 1992 and 1993, 43 sightings of California sea lions were made (Gerrodette and Palacios 1996); however, these sightings were made north of the proposed survey area, off the Baja California Peninsula. However, occasional sightings have been reported off Nayarit, Guerrero, Oaxaca, and Chiapas (Meraz and Sánchez-Díaz 2008; Arroyo 2017). There are no sightings in or near the proposed survey area in the OBIS database (OBIS 2024). During summer 2020, a stranding event resulting in 48 mortalities along Baja California was likely linked to a harmful algal bloom (Elorriaga-Verplancken et al. 2022).

V. TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

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

L-DEO requests an IHA pursuant to Section 101 (a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic surveys in the ETP during spring 2025. The operations outlined in § I have the potential to take marine mammals by harassment. Sounds would be generated by the airguns used during the surveys, by echosounders, and by general vessel operations. "Takes" by harassment would potentially result when marine mammals near the activity are exposed to the pulsed sounds, such as those generated by the airguns. The effects would depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel.

At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No Level A takes, take by serious injury or lethal takes are expected, given the nature of the planned operations, the mitigation measures that are planned (see § XI, MITIGATION MEASURES), in addition to the general avoidance by marine mammals of loud sound.

VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN

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

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

VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS

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

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

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Then we summarize the potential impacts of operations by the echosounders. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.
- Finally, we estimate the numbers of marine mammals that could be affected by the proposed surveys in the ETP. As called for in § VI, this section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned surveys.

Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2016, 2019, 2022; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017; Weilgart 2017; Bröker 2019; Rako-Gospić and Picciulin 2019; Burnham 2023). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury (Southall et al. 2007; Le Prell 2012). Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if the impulses have very short rise times (e.g., Morell et al. 2017). However, the impulsive nature of sound is range-dependent (Hastie et al. 2019; Martin et al. 2020) and may become less harmful over distance from the source (Hastie et al. 2019). TTS is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman et al. 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016; Houser 2021). Although the possibility cannot be entirely excluded, it would be unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals were encountered during an active survey, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance

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

Masking

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

Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Kyhn et al. (2019) reported that baleen whales and seals were likely masked over an extended period of time during four concurrent seismic surveys in Baffin Bay, Greenland. Nieukirk et al. (2012), Blackwell et al. (2013), and Dunlop (2018) also noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012, 2020; Blackwell et al. 2013, 2015; Thode et al. 2020; Fernandez-Betelu et al. 2021; Noad and Dunlop 2023). 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. Kastelein et al. (2023a) reported masking release at various frequencies in harbor seals exposed to noise with fluctuating amplitude. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses.

Disturbance Reactions

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

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012, 2018). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013a). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Lusseau and Bejder 2007; Weilgart 2007, 2023; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Kastelein et al. (2019a) surmised that if disturbance by noise would displace harbor porpoises from a feeding area or otherwise impair foraging ability for a short period of time (e.g., 1 day), they would be able to compensate by increasing their food consumption following the disturbance.

Southall et al. (2023) proposed data collection and analysis methods to examine the potential effects, including at the population level, of seismic surveys on whales. There have been several studies have attempted modeling to assess consequences of effects from underwater noise at the population level; this has proven to be complicated by numerous factors including variability in responses between individuals (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017; Dunlop et al. 2021; Gallagher et al. 2021; McHuron et al. 2021; Mortensen et al. 2021). Booth et al. (2020) examined monitoring methods for population consequences.

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species; detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys; many data gaps remain where exposure criteria are concerned (Southall 2021).

Baleen Whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995). Kavanagh et al. (2019) analyzed more than 8000 hr of cetacean survey data in the northeastern Atlantic Ocean to determine the effects of the seismic surveys on cetaceans. They found that sighting rates of baleen whales were significantly lower during seismic surveys compared with control surveys.

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

Dunlop et al. (2015) reported that migrating humpback whales in Australia responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun(s) was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b, 2020). Overall, the results showed that humpbacks were more likely to avoid active small airgun sources (20 and 140 in^3) within 3 km and received levels of at least 140 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017a). Responses to ramp up and use of a large 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c).

Humpbacks deviated from their southbound migration when they were within 4 km of the active large airgun source, where received levels were >130 dB re 1 μPa² · s (Dunlop et al. 2017b, 2018). These results are consistent with earlier studies (e.g., McCauley et al. 2000). Dunlop et al. (2020) found that humpback whales reduce their social interactions at greater distances and lower received levels than regulated by current mitigation practices.

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015; Stone et al. 2017). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007). During a seismic survey in Cook Inlet, AK, wide-scale displacement was documented for humpback whales; acoustic detections were reduced or absent during the seismic survey period, but detections increased after the survey finished (Castellote et al. 2020).

Matthews and Parks (2021) summarized the known responses of right whales to sounds; however, there are no data on reactions of right whales to seismic surveys. Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 μPa; at SPLs <108 dB re 1 μPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 μPa² · s, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 μPa² · s, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 μPa² · s. Thode et al. (2020) reported similar changes in bowhead whale vocalizations when data were analyzed for the period 2008–2014. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

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

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) and in 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b). Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during the seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs above ~163 dB re 1 μPa_{rms} (Johnson et al. 2007; Nowacek et al. 2012, 2013b). In contrast, despite rigorous monitoring and mitigation measures during multiple seismic surveys in 2015 (Aerts et al. 2022; Rutenko et al. 2022), data collected during a program with multiple seismic surveys in 2015 showed short-term and long-term displacement of animals from the feeding area, at least short-term behavioral changes, and responses to lower sound levels than expected (Gailey et al. 2017, 2022a,b; Sychenko et al. 2017). However, stochastic dynamic programming (SDP) model predictions showed similar reproductive success and habitat use by gray whales with or without exposure to airgun sounds during the 2015 program (Schwarz et al. 2022).

Gray whales in B.C., Canada, exposed to seismic survey sound levels up to ~170 dB re 1 μPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of Balaenoptera (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994–2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015; Stone et al. 2017). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015; Stone et al. 2017). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015; Stone et al. 2017). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015; Stone et al. 2017). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population continued to feed off Sakhalin Island every summer, despite seismic surveys in the region. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years. Pirotta et al. (2018) used a dynamic state model of behavior and physiology to assess the consequences of disturbance (e.g., seismic surveys) on whales (in this case, blue whales). They found that the impact of localized, acute disturbance (e.g., seismic surveys) depended on the whale’s behavioral response, with whales that remained in the affected area having a greater risk of reduced reproductive success than whales that avoided the disturbance. Chronic, but weaker disturbance (e.g., vessel traffic) appeared to have less effect on reproductive success.

Toothed Whales.—Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Monaco et al. 2016; Stone et al. 2017; Barkaszi and Kelly 2024). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994–2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015; Stone et al. 2017). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015; Stone et al. 2017). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015; Stone et al. 2017). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015; Stone et al. 2017).

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

Similarly, an analysis of PSO data from multiple seismic surveys in the northern Gulf of Mexico from 2002–2015 found that delphinids occurred significantly farther from the airgun array when it was active versus silent (Barkaszi and Kelly 2024). Dolphins were sighted significantly farther from the active array during operations at minimum power versus full power. Blackfish were seen significantly farther from the array during ramp up versus full source and minimum source operations, and they were seen significantly closer to the array when it was silent versus during full source, minimum source, and ramp up operations.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland, (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment. However, Heide-Jørgensen et al. (2021) did report avoidance reaction at distances >11 km from an active seismic vessel, as well as an increase in travel speed and changes in direction of travel at distances up to 24 km from a seismic source; however, no long-term effects were reported. Tervo et al. (2021) reported that narwhal buzzing rates decreased in response to concurrent ship noise and airgun pulses (being 50% at 12 km from ship) and that the whales discontinued to forage at 7–8 km from the vessel. Tervo et al. (2023) also noted that narwhals showed increased shallow diving activity and avoided deeper diving, resulting in a reduction in foraging, when exposed to combined ship sounds and airgun pulses. Both studies found that exposure effects could still be detected >40 km from the vessel (Tervo et al. 2021, 2023).

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). Winsor et al. (2017) outfitted sperm whales in the Gulf of Mexico with satellite tags to examine their spatial distribution in relation to seismic surveys. They found no evidence of avoidance or changes in orientation by sperm whales to active seismic vessels. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015; Stone et al. 2017). Foraging behavior can also be altered upon exposure to airgun sound (e.g., Miller et al. 2009), which according to Farmer et al. (2017), could have significant consequences on individual fitness. Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity and periods with airgun operations (Sidorovskaia et al. 2014). Barkaszi and Kelly (2024) found that sperm whales occurred at significantly farther CPAs from airgun array during full array activity versus silence based on data from multiple seismic surveys in the northern Gulf of Mexico during 2002–2015; similar results were found for both dwarf and pygmy sperm whales.

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it would be likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994–2010 indicated that detection rates of beaked whales were significantly higher (p<0.05) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015; Stone et al. 2017). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005). Data from multiple seismic surveys in the northern Gulf of Mexico from 2002–2015 showed no significant difference in beaked whale CPA distances to the airgun array during full power versus silent periods, but the sample size was small, and mean CPA was larger than in other species groups (Barkaszi and Kelly 2024).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007). Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015; Stone et al. 2017). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015; Stone et al. 2017). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Similar avoidance behavior and/or decreases in echolocation signals during 3-D seismic operations were reported for harbor porpoise in the North Sea (Sarnocińska et al. 2020). In a captive facility, harbor porpoise showed avoidance of a pool with elevated sound levels, but search time for prey within that pool was no different than in a quieter pool (Kok et al. 2017). During a seismic survey in Cook Inlet, AK, wide-scale displacement was documented for harbor porpoises; acoustic detections were reduced or absent during the seismic survey, but detections increased after the survey finished (Castellote et al. 2020).

Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012c) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013c). Van Beest et al. (2018) exposed five harbor porpoise to a single 10 in^3 airgun for 1 min at 2–3 s intervals at ranges of 420–690 m and levels of 135–147 dB $\mu Pa^2 \cdot s$. One porpoise moved away from the sound source but returned to natural movement patters within 8 h, and two porpoises had shorter and shallower dives but returned to natural behaviors within 24 h.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans. According to Scholik-Schlomer (2015), NMFS is developing new guidance for predicting behavioral effects. As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017; Tyack and Thomas 2019).

Pinnipeds.—Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994–2010 showed that the detection rate for gray seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015; Stone et al. 2017). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015; Stone et al. 2017). There were no significant differences in CPA distances of gray or harbor seals during seismic vs. non-seismic periods (Stone 2015; Stone et al. 2017). Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses; only mild behavioral responses were observed.

Hearing Impairment and Other Physical Effects

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b, 2023a; Popov et al. 2011, 2013; Ketten 2012; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a, 2016a,b, 2017, 2018, 2019a,b, 2020a,b,c,d,e,f, 2021a,b, 2022a,b; Supin et al. 2016). Additionally, Gransier and Kastelein (2024) found that audiograms are not good predictors of frequency-dependent susceptibility to TTS.

Studies have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016). Bottlenose dolphins exposed to 10-ms impulses at 8 kHz with SELs of 182–183 dB re 1 $\mu Pa^2 \cdot s$ produced a TTS of up to 35 dB (Mulsow et al. 2023).

Studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012; Mulsow et al. 2023). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b, 2017) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise. When a porpoise was exposed to 10 and 20 consecutive shots (mean shot interval ~17 s) from two airguns with a SEL_{cum} of 188 and 191 $\mu Pa^2 \cdot s$, respectively, significant TTS occurred at a hearing frequency of 4 kHz and not at lower hearing frequencies that were tested, despite the fact that most of the airgun energy was <1 kHz; recovery occurred within 12 min post exposure (Kastelein et al. 2017).

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016; Nachtigall et al. 2018; Finneran 2020; Kastelein et al. 2020g; Finneran et al. 2023b,c, 2024).

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

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013a,b, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Based on studies that exposed harbor porpoises to one-sixth-octave noise bands ranging from 1–88.4 kHz, Kastelein et al. (2019c,d, 2020d,e,f) noted that susceptibility to TTS increases with an increase in sound less than 6.5 kHz but declines with an increase in frequency above 6.5 kHz. At a noise band centered at 0.5 kHz (near the lower range of hearing), the SEL required to elicit a 6 dB TTS is higher than that required at frequencies of 1–88.4 kHz (Kastelein et al. 2021a). Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 μPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{\text{eq-fast}}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, according to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Simulation modeling to assess the risk of sound exposure to marine mammals (gray seal and harbor porpoise) showed that SEL is most strongly influenced by the weighting function (Donovan et al. 2017). Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001; Kastelein et al. 2013a). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. A maximum TTS >45 dB was elicited from a harbor seal exposed to 32 kHz at 191 dB SEL (Kastelein et al. 2020c). For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Harbor seals appear to be equally susceptible to incurring TTS when exposed to sounds from 2.5–40 kHz (Kastelein et al. 2020a,b), but at frequencies of 2 kHz or lower, a higher SEL was required to elicit the same TTS (Kastelein et al. 2020c). Harbor seals may be able to decrease their exposure to underwater sound by swimming just below the surface where sound levels are typically lower than at depth (Kastelein et al. 2018). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed. Similarly, no TTS was measured when a bearded seal was exposed to a single airgun pulse with an unweighted SEL of 185 dB and an SPL of 207 dB; however, TTS was elicited at 400 Hz when exposed to four to ten consecutive pulses with a cumulative unweighted SEL of 191–195 dB, and a weighted SEL of 167–171 dB (Sills et al. 2020). Kastelein et al. (2021b) found that susceptibility of TTS of California sea lions exposed to one-sixth-octave noise bands centered at 2 and 4 kHz is similar to that of harbor seals. Kastelein et al. (2024) reported that TTS onset in California sea lions is not as closely associated with their hearing threshold as previously thought.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

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

The noise exposure criteria for marine mammals that were released by NMFS (2016b, 2018) accounted for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016b, 2018), but include all marine mammals (including sirenians), and a re-classification of hearing groups. NMFS (2024) incorporated Southall et al. (2019) recommendations into updated guidance regarding noise exposure criteria. For impulsive sounds, such as airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including Low-frequency (LF) cetaceans (e.g., baleen whales), high-frequency (HF) cetaceans (e.g., most delphinids; previously known as mid-frequency cetaceans), very-high frequency (VHF) cetaceans (e.g., porpoise and *Kogia* spp.; previously known as HF cetaceans), phocid pinnipeds underwater (PW), and otariid pinnipeds underwater (OW).

It should be recognized that there are a number of limitations and uncertainties associated with injury criteria (Southall et al. 2007). Lucke et al. (2020) caution that some current thresholds may not be able to accurately predict hearing impairment and other injury to marine mammals due to noise. Tougaard et al. (2022) indicate that there is empirical evidence to support the thresholds for very-high frequency cetaceans and pinnipeds in water, but caution that above 10 kHz for porpoise and outside of 3–16 kHz for seals, there are differences between the TTS thresholds and empirical data. Tougaard et al. (2023) also noted that TTS-onset thresholds for harbor porpoise are likely impacted by the experimental methods used (e.g., behavioral vs. brain stem recordings, and stationary vs. free-swimming animals), in particular for noise exposure >10 kHz.

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Various authors have reported that sound could be a potential source of stress for marine mammals (e.g., Wright et al. 2011; Atkinson et al. 2015; Houser et al. 2016; Lyamin et al. 2016; Yang et al. 2021). Gray and Van Waerebeek (2011) suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. Williams et al. (2022)

reported an increase in energetic cost of diving by narwhals that were exposed to airgun noise, as they showed marked cardiovascular and respiratory reactions.

It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale strandings along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding. Morell et al. (2021) also reported evidence of hearing loss in a harbor porpoise that stranded on the Dutch coast. Morell et al. (2020) described new methodology that visualizes scars in the cochlea to detect hearing loss in stranded marine mammals.

Since 1991, there have been 72 marine mammal UMEs in the U.S. (NOAA 2024c). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (https://www.energy.senate.gov/public/index.cfm/2016/5/hearing-is-examine-the-bureau-of-ocean-energy-management-s-2017-2022-ocs-oil-and-gas-leasing-program), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico. Similarly, the large whale UME Core Team found that seismic testing did not contribute to the 2015 UME involving humpbacks and fin whales from Alaska to B.C. (Savage 2017).

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

Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed surveys. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

There has been some attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales off Madagascar (Southall et al. 2013). During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event was the first known marine mammal mass stranding closely associated with the operation of an MBES. A leading scientific expert knowledgeable about MBES expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

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

Lurton (2016) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system like that used on R/V *Langseth*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioral response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2016:209). However, Ruppel et al. (2022) found that MBESs, SBPs, sidescan sonars, ADCPs, and pingers are unlikely to result in take of marine mammals as these sources typically operate at frequencies inaudible to marine mammals, have low source and received levels, narrow beams, downward directed transmission, and/or have low exposure (e.g., short pulse lengths, intermittency of pulses).

There is little information available on marine mammal behavioral responses to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency, mid-frequency, and high-frequency active sonars (see review by Southall et al. 2016). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

During a recent study, group vocal periods (GVP) were used as proxies to assess foraging behavior and use of habitat by Cuvier's beaked whales during multibeam mapping with a 12 kHz MBES in southern California (Varghese et al. 2021). The study found that there was no significant difference between GVP during multibeam mapping and non-exposure periods, suggesting that the level of foraging and habitat use likely did not change during multibeam mapping. During an analogous study assessing naval sonar (McCarthy et al. 2011), significantly fewer GVPs were recorded during sonar transmission (McCarthy et al. 2011; Varghese et al. 2020).

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

Frankel and Stein (2020) reported that gray whales responded to a 21–25 kHz active sonar by deflecting 1–2 km away from the sound. Sperm whales exposed to sounds from a low-frequency 1–2 kHz sonar transitioned to non-foraging and non-resting states, but did not respond to 4.7–5.1 kHz or 6–7 kHz sonar signals (Isojunno et al. 2016). Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by gray seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2017), and significantly fewer beaked whale vocalizations were detected while an EK60 echosounder was active vs. passive (Cholewiak et al. 2017).

Despite the aforementioned information that has recently become available, this Draft EA remains in agreement with the assessment presented in § 3.4.7, 3.6.7, 3.7.7, and 3.8.7 of the PEIS that operation of MBESs, SBPs, and pingers would not be likely to impact marine mammals and would not be expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

Other Possible Effects of Seismic Surveys

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

Vessel noise from R/V *Langseth* could affect marine animals in the proposed survey area. 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 20–300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014; Veirs et al. 2016; Kyhn et al. 2019; Landrø and Langhammer 2020); low levels of high-frequency sound from vessels have been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise have also been shown to affect foraging behavior (Teilmann et al. 2015; Wisniewska et al. 2018; Tervo et al. 2023), habitat use (e.g., Rako et al. 2013; Carome et al. 2022; Gannier et al. 2022), and swim speeds and movement (e.g., Sprogis et al. 2020; Martin et al. 2023a) of cetaceans. Vessel noise has also been shown to affect the dive behavior of pinnipeds (Mikkelsen et al. 2019). 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, 2018; Erbe et al. 2016; Jones et al. 2017; Putland et al. 2017; Cholewiak et al. 2017; Groenewoud 2023). 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; Popov et al. 2020; Branstetter and Sills 2022). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. Yurk et al. (2023) suggested that killer whales could avoid masking by using adaptive call design or vocalizing at different frequencies depending on noise levels in their environment.

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 vessels, 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; 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; Bittencourt et al. 2017; Fornet et al. 2018; Laute et al. 2022; Brown et al. 2023; Radtke et al. 2023).

In contrast, Sportelli et al. (2024) found that the whistle rates of captive bottlenose dolphins did not differ significantly during the initial sound exposure (e.g., ship noise) compared with before exposure. Similarly, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016). However, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017), and spotted seals increased the source levels of their growls in response to increased ambient noise (Yang et al. 2022). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals.

In addition to masking, Erbe et al. (2019) noted that ship noise can elicit physical and behavioral responses in marine mammals, as well as stress. For example, Rolland et al. (2012) showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. However, shipping noise is typically not thought to produce sounds capable of eliciting hearing damage. Trigg et al. (2020) noted that gray seals are not at risk of TTS from shipping noise, based on modeling. 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; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

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). Martin et al. (2023b) reported no long-range (up to 50 km) responses of bowhead whales to passing vessels; responses <8 km from vessels could not be examined. 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) and killer whales (Williams et al. 2021). 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). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). 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. Tyson et al. (2017) suggested that a juvenile green sea turtle dove during vessel passes and remained still near the sea floor.

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

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. Similarly, Currie et al. (2017) found a significant decrease in close encounters with humpback whales in the Hawaiian Islands, and therefore reduced likelihood of ship strike, when vessels speeds were below 12.5 kt. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels. The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but would be extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. Humpback whales are the most commonly struck large whale species in the ETP (Ransome et al. 2021), although blue whales and Bryde's whales have also been struck off Mexico (Lazcano-Pacheco et al. 2022). There has been no history of marine mammal vessel strikes with R/V *Langseth*, or its predecessor, R/V *Maurice Ewing* over the last two decades.

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

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. No injurious takes (Level A) would be expected; however, Level A modeling is provided in Appendix A. In the sections below, we describe methods to estimate the number of potential exposures to Level B sound levels for the low-energy surveys, and we present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be harassed or disturbed appreciably by Level B sound levels produced by the seismic surveys in the ETP.

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

Basis for Estimating "Takes"

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of seismic surveys. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound.

The numbers of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) on one or more occasions have been estimated using a method recommended by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting seismic tracklines that could be surveyed on one day (up to 222 km) that have the same or similar proportion of water depths to be surveyed as during the entire survey (in this case, all deep water >1000 m deep). The area expected to be ensonified on a single day was determined by multiplying the number of km to be surveyed on one day by two times the radius of the 160-dB (Level B) isopleth. The ensonified area, increased by 25%, was then multiplied by the number of seismic days (7). This is equivalent to adding an additional 25% to the proposed line km (Appendix B). The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as R/V *Langseth* approaches. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound.

We used habitat-based stratified marine mammal densities for summer for the ETP when available (Barlow et al. 2009) and densities for the ETP from NMFS (2015) for all other species (Table 3). For the sei whale, for which NMFS (2015) reported a density of zero, we used the spring density for Baja from DoN (2017b). The habitat-based density models based on Barlow et al. (2009) consisted of 100 km x 100 km grid cells; densities in the grid cells that overlapped the survey area off the state of Guerrero were averaged. As the grid cells were large, the densities included areas from shallow (<100 m) to deep (>1000 m) water.

Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the North Pacific Ocean, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (Forney and Barlow 1998; Buchanan et al. 2001; Ferrero et al. 2002; Philbrick et al. 2003; Escorza-Treviño 2009). Thus, for some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys. However, the approach used here is based on the best available data.

Table 4 shows the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic surveys if no animals moved away from the survey vessel, along with the *Requested Take Authorization*. It should be noted that the exposure estimates assume that the proposed surveys would be completed; in fact, the calculated takes for marine mammals ***have been increased by 25%***. Thus, the following estimates of the numbers of marine mammals potentially exposed to sounds ≥160 dB re 1 μPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

TABLE 3. Densities of marine mammals in the Pacific waters of Mexico (Barlow et al. 2009) and the wider ETP (NMFS 2015). Densities in bold were used to estimate Level B takes.

	Density (#/km^2) in Survey Area [Barlow et al. 2009]	Density (#/km^2) in wider ETP [NMSF 2015]	Density (#/km^2)	Spring density (#/km^2) for Baja [DoN 2017]	Ferguson and Barlow (2001)
Baleen Whales					
Humpback whale		**0.00013**		0.00192	
Minke whale		**0.00001**		0.00061	
Bryde's whale	**0.00042**	0.00049		0.00002	
Fin whale		**0.00003**		0.00181	
Sei whale[1]		0	**0.00005**	**0.00005**	
Blue whale	**0.00008**	0.00019		0.00007	
Odontocetes					
Sperm whale		**0.00019**			0.00022
Cuvier's beaked whale	**0.00089**	0.00094			0.00562
Longman's beaked whale		**0.00004**		0	0.00000
Mesplodon spp.	**0.00035**	0.00119		0.00217	0.00372
Blaineville's beaked whale[2]					0.00000
Ginkgo-toothed beaked whale[2]					
Deraniyagala's beaked whale[2]					
Pygmy beaked whale[2]					0.00000
Risso's dolphin	**0.01555**	0.00517		0.00532	0.04741
Rough-toothed dolphin	**0.00926**	0.00504		0	0.03008
Common bottlenose dolphin	**0.03631**	0.01573		0.00843	0.02317
Pantropical spotted dolphin	**0.13066**	0.12263		0	0.35878
Spinner dolphin (whitebelly)	**0.00173**	0.04978		0	0.25462
Spinner dolphin (eastern)	**0.12812**			0	
Striped dolphin	**0.03365**	0.04516		0.13823	0.03168
Common dolphin	**0.04396**	0.14645		0.45049	0.01203
Fraser's dolphin		**0.01355**		0	0.00000
Short-finned pilot whale[3]	**0.00388**	0.02760		0.00038	0.00000
Killer whale		**0.00040**		0.00009	0.00021
False killer whale		**0.00186**		0	0.00000
Pgymy killer whale		**0.00183**		0	0.01469
Melon-headed whale		**0.00213**		0	0.00000
Dwarf sperm whale		0.00053		0.00366	0.02436
Kogia spp.	**0.00004**				
Otariids					
Guadalupe fur seal		**0.00741**		0.0083	
California sea lion[4]		**0.01626**		0.0529	

1 Density for Baja California (DoN 2017b).
2 Densities not available.
3 Densities are for *Globicephala* spp.
4 10% of the density from the wider ETP was used to account for the fact that California sea lions typically do not occur in water >1000 m.

TABLE 4. Estimates of the possible numbers of individual marine mammals that could be exposed to Level B sounds during the proposed seismic surveys in the Pacific waters of Mexico.

Species	Estimated Density (#/km²)	Regional Population Size[1]	Level B Ensonified Area (km²)	Level B Takes	% of Pop. (Total Takes)[2]	Requested Level A+B Take Authorization[3]
Baleen Whales						
Humpback whale[4]	0.00013	2,566	1,707	0	0.04	*1*
Minke whale	0.00001	*115*	1,707	0	0.87	*1*
Bryde's whale	0.00042	649	1,707	1	0.31	**2**
Fin whale	0.00003	145	1,707	0	0.69	*1*
Sei whale	0.00005	*29,600*	1,707	0	<0.01	*1*
Blue whale	0.00008	773	1,707	0	0.26	**2**
Odontocetes						
Sperm whale	0.00019	2,810	1,707	0	0.28	**8**
Cuvier's beaked whale	0.00089	*20,000*	1,707	2	0.01	2
Longman's beaked whale	0.00004	*1,007*	1,707	0	0.30	**3**
Mesoplodon spp.	0.00035	*25,300*	1,707	1	N.A.	N.A.
Blaineville's beaked whale	N.A.	*25,300*	1,707	N.A.	0.01	**3**
Ginkgo-toothed beaked whale	N.A.	*25,300*	1,707	N.A.	0.01	**3**
Deraniyagala's beaked whale	N.A.	*25,300*	1,707	N.A.	0.01	**3**
Pygmy beaked whale	N.A.	*25,300*	1,707	N.A.	0.01	**3**
Risso's dolphin	0.01555	24,084	1,707	27	0.11	27
Rough-toothed dolphin	0.00926	37,511	1,707	16	0.04	16
Common bottlenose dolphin	0.03631	61,536	1,707	62	0.10	62
Pantropical spotted dolphin	0.13066	146,296	1,707	223	0.15	223
Spinner dolphin (whitebelly)	0.00173	186,906	1,707	3	0.07	**134**
Spinner dolphin (eastern)	0.12812	186,906	1,707	219	0.12	219
Striped dolphin	0.03365	128,867	1,707	57	0.05	**61**
Common dolphin	0.04396	283,196	1,707	75	0.09	**254**
Fraser's dolphin	0.01355	*289,300*	1,707	23	0.14	**395**
Short-finned pilot whale	0.00388	3,348	1,707	7	0.54	**18**
Killer whale	0.00040	852	1,707	1	0.59	**5**
False killer whale	0.00186	*39,600*	1,707	3	0.03	**11**
Pgymy killer whale	0.00183	*38,900*	1,707	3	0.07	**28**
Melon-headed whale	0.00213	*45,400*	1,707	4	0.44	**199**
Dwarf and pygmy sperm whales[5]	0.00004	*11,200*	1,707	0	0.02	**2**
Otariids						
Guadalupe fur seal	0.00741	*34,107*	1,707	13	0.04	13
California sea lion	0.00163	*105,000*	1,707	3	<0.01	3

N.A. means not applicable or not available.
1 Population sizes are for Pacific waters of Mexico, except those in italics are for the ETP or wider Pacific (see Table 3).
2 Requested take authorization expressed as % of population.
3 Requested take authorization rounded up to 1 (in italics) or to mean group size (in bold).
4 Take is expected to be from the endangered Central America DPS.
5 Takes are expected to be dwarf sperm whales.

There is uncertainty about the representativeness of the data and the assumptions used to estimate exposures. Thus, for some species, the densities derived from the abundance models described above may not precisely represent the densities that would be encountered during the proposed seismic surveys. The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all marine mammals. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment".

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in the NSF/USGS PEIS. The 160-dB_{rms} criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013). The context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (e.g., Ellison et al. 2012; NMFS 2013; Hückstädt et al. 2020; Hastie et al. 2021; Southall et al. 2021; Booth et al. 2022; Miller et al. 2022). Southall et al. (2021) provided a detailed framework for assessing marine mammal behavioral responses to anthropogenic noise and note that use of a single threshold can lead to large errors in prediction impacts due to variability in responses between and within species.

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

VIII. ANTICIPATED IMPACT ON SUBSISTENCE

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

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

IX. Anticipated Impact on Habitat

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

The proposed seismic surveys would not result in any permanent impact on habitats used by marine mammals or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in § VII, above. Effects of seismic sound on marine invertebrates, marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations. Therefore, it is highly unlikely that there would be significant impacts on populations from the proposed low-energy surveys.

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

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

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

XI. Mitigation Measures

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

Numerous marine mammals species are known to occur in the proposed survey area. To minimize the likelihood that impacts would occur to the species and stocks, airgun operations would be conducted in accordance with the MMPA and the ESA, including obtaining permission for incidental harassment or incidental ‘take’ of marine mammals and other endangered species and following requirements issued in the IHA and associated Incidental Take Statement (ITS).

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity. The procedures described here are based on protocols used during previous L-DEO seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al. (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017).

Planning Phase

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

1. *Energy Source*—Part of the considerations for the proposed marine seismic surveys was to evaluate whether the research objectives could be met with a smaller energy source. It was decided that the scientific objectives could be met using a low-energy source consisting of two 45/105 in^3 GI guns (total volume of 90 in^3) at a tow depth of ~3 m. The scientific objectives for the proposed surveys could not be met using a smaller source.

2. *Survey Location and Timing*—The PIs, along with L-DEO and NSF, considered potential times to carry out the proposed surveys, key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using R/V *Langseth*. Although most marine mammals are expected to occur in the proposed survey area throughout the year, the humpback whale is common in the region seasonally from December through March. For the previous L-DEO surveys off Mexico (LGL 2022), NMFS recommended that nearshore portions (within ~33 km of the coast) of the surveys occur after May 1st when most of the humpback whales will have migrated northward. Thus, late spring (May–June) is the most practical season for the proposed surveys based on the occurrence of marine mammals, weather conditions, and other operational requirements.
3. *Mitigation Zones*—During the planning phase, mitigation zones for the proposed seismic surveys were not derived from the farfield signature but calculated based on modeling by L-DEO for the Level B (160 dB re $1\mu Pa_{rms}$) threshold. The proposed surveys would acquire data with the 2-GI airgun array at a tow depth of ~3 m. L-DEO model results are used to determine the 160-dB_{rms} radius for the 2-GI airgun array in deep water (>1000 m) down to a maximum water depth of 2000 m, as animals are generally not anticipated to dive below 2000 m (Costa and Williams 1999).

Mitigation During Operations

Marine mammals and sea turtles are known to occur in the proposed survey area. However, the number of individual animals expected to be approached closely during the proposed activities are expected to be relatively small in relation to regional population sizes. To minimize the likelihood that potential impacts could occur to the species and stocks, monitoring and mitigation measures proposed during the operational phase of the proposed activities, which are consistent with the PEIS and past IHA and incidental take statement (ITS) requirements, include: (1) monitoring by PSOs for marine mammals, and ESA-listed sea turtles and seabirds (diving/foraging) near the vessel, and observing for potential impacts of acoustic sources on fish; (2) PSO data and documentation; and (3) mitigation during operations (speed or course alteration; shut down and ramp up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats).

It would be unlikely that concentrations of large whales would be encountered within the 160-dB isopleth, but if they were, they would be avoided. In order to prevent ship strikes, vessel speed would be reduced to 10 kt or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed (during seismic operations vessel speed would only be ~4.5–5 kt).

As an anticipated requirement of the IHA, an extended 500-m shut down zone would be established for all beaked whales, dwarf and pygmy sperm whales, a large whale with calf, and groups of six or more large whales; the EZ for all other marine mammals would be 100 m (with the exception of bow-riding dolphins). Mitigation measures that would be adopted during the proposed surveys include (1) shut down procedures and (2) ramp up procedures. These measures are proposed by L-DEO based on past experience and for consistency with the PEIS.

The proposed operational mitigation measures are standard for seismic cruises, per the PEIS. Three independently contracted PSOs would be on board the survey vessel with rotating shifts to allow two observers to monitor for marine species during daylight hours. With the proposed monitoring and mitigation provisions, potential effects on most, if not all, individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Ultimately, survey operations would be conducted in accordance with all applicable international and U.S. federal regulations, including IHA and ITS requirements.

Shut Down Procedures

Although Level A takes would not be anticipated for the 2 GI gun surveys, for other low-energy seismic surveys, NMFS has required PSOs to establish and monitor a 100-m shut down EZ for marine mammals and a 100-m buffer zone beyond the EZ (total 200 m). NMFS recently also required PSOs to establish and monitor a 100-m EZ for shut downs for sea turtles and to monitor an additional 100-m buffer zone beyond the EZ, during low-energy surveys. A 100-m EZ for diving/foraging ESA-listed seabirds would also be followed. Following a shut down for a marine mammal, airgun activity would not resume until the animal has cleared the EZ. The marine mammal would be considered to have cleared the EZ if

- it was visually observed to have left the EZ, or
- it was not seen within the zone for 15 min in the case of small odontocetes and pinnipeds, ESA-listed seabirds and sea turtles, or
- it was not seen within the zone for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales.

The airgun array would be ramped up after a shut down for marine mammals. For ESA-listed sea turtles or seabirds observed in the EZ, a shut down not requiring ramp up (i.e., a “pause”) is to be implemented until the sea turtle or seabird is no longer observed in the EZ (i.e., 15 minutes). Ramp up procedures are described below.

Ramp Up Procedures

A ramp up procedure would be followed when the airgun array begins operating after a specified period without airgun operations. It is proposed that this period would be 30 min, as long as PSOs have maintained constant visual and acoustic observations and no detections within the EZ have occurred. Ramp up would not occur if a marine mammal has not cleared the EZ as described earlier. As previously noted, for shut downs implemented for sea turtles and ESA-listed seabirds, no ramp up would be required, as long as the animal was no longer observed within the EZ. Ramp up would begin by activating a single GI airgun and adding the second GI airgun after 5 minutes so that the source level of the array would increase in steps not exceeding 6 dB per 5-min period. During ramp up, the PSOs would monitor the EZ, and if marine mammals or ESA-listed sea turtles/seabirds (diving/foraging) are sighted, a shut down would be implemented as though the full array were operational.

XII. Plan of Cooperation

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

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

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

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

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

Not applicable. The proposed activity would take place in the ETP, and no activities would take place in traditional Arctic subsistence hunting area.

XIII. Monitoring and Reporting Plan

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

L-DEO proposes to sponsor marine mammal monitoring during the present project, in order to implement the proposed mitigation measures that require real-time monitoring and to satisfy the expected monitoring requirements of the IHA. L-DEO's proposed Monitoring Plan is described below. L-DEO understands that this Monitoring Plan would be subject to review by NMFS and that refinements may be required. The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. L-DEO is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

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

During seismic operations, three PSOs would be based aboard R/V *Langseth*. All PSOs would be appointed by L-DEO with NMFS concurrence. During the majority of seismic operations, two PSOs would monitor for marine mammals around the seismic vessel. Use of two simultaneous observers would increase the effectiveness of detecting animals around the source vessel. PSO(s) would be on duty in shifts of duration no longer than 4 h, or per the IHA. Other crew would also be instructed to assist in detecting marine mammals and implementing mitigation requirements (if practical). Before the start of the seismic surveys, the crew would be given additional instruction regarding how to do so.

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

PSO Data and Documentation

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

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

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

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

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

Results from the vessel-based observations would provide

1. the basis for real-time mitigation (airgun power down or shut down);
2. information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS;
3. data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted;
4. information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity;

5. data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity; and
6. any observations of fish potentially affected by the sound sources.

A report would be submitted to NMFS and NSF within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring and would summarize the dates and locations of seismic operations and all marine mammal observations. The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

XIV. Coordinating Research to Reduce and Evaluate Incidental Take

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

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

XV. Literature Cited

Aarts, G., A.M. von Benda-Beckmann, K. Lucke, H.Ö. Sertlek, R. Van Bemmelen, S.C. Geelhoed, S. Brasseur, M. Scheidat, F.P.A. Lam, H. Slabbekoorn, and R. Kirkwood. 2016. Harbour porpoise movement strategy affects cumulative number of animals acoustically exposed to underwater explosions. **Mar. Ecol. Prog. Ser.** 557:261-275.

Acevedo-Gutierrez, A. 1996. Lista de mamíferos marinos en Golfo Dulce e Isla del Coco, Costa Rica. **Rev. Biol. Trop.** 44(2):933- 934.

Acosta, A., N. Nino-Rodriquez, M.C. Yepes, and O. Boisseau. 2017. Mitigation provisions to be implemented for marine seismic surveying in Latin America: a review based on fish and cetaceans. **Aquat. Biol.** 199-216.

Aerts, L., M.R. Jenkerson, V.E. Nechayuk, G. Gailey, R. Racca, A.L. Blanchard, L.K. Schwarz, and H.R. Melton. 2022. Seismic surveys near gray whale feeding areas off Sakhalin Island, Russia: assessing impact and mitigation effectiveness. **Environ. Monit. Assess.** 194 (Suppl. 1):746. https://doi.org/10.1007/s10661-022-10016-9.

Arcos-Aguilar, R., F. Favoretto, J.A. Kumagai, V. Jiménez-Esquivel, A.L. Martínez-Cruz, and O. Aburto-Oropeza. 2021. Diving tourism in Mexico–Economic and conservation importance. **Mar. Pol.** 126:104410.

Aguilar A. and R. García-Vernet. 2018. Fin whale *Balaenoptera physalus*. p. 368-371 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Aguilar de Soto, N., N. Delorme, J. Atkins, S. Howard, J. Williams, and M. Johnson. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. **Sci. Rep.** 3:2831.

Aguilar Soto, N., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli, and J.F. Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? **Mar. Mamm. Sci.** 22(3):690-699.

AIDCP (Agreement on the International Dolphin Conservation Program). 2024. 49th meeting of the parties. Document AIDCP-49-02. Accessed October 2024 at https://www.iattc.org/GetAttachment/0c3cd2a0-560f-4809-85c1-d7f44e03fa01/AIDCP-49-02_Report-on-International-Dolphin-Conservation-Program.pdf

Allen, R.L. 1985. Dolphins and the purse-seine fishery for yellowfin tuna. p. 236-252 *In*: J.R. Beddington, R.J.H. Beverton and D.M. Lavigne (eds.), Marine mammals and fisheries. George Allen & Unwin, London, U.K. 354 p.

Anderson, R.C., R. Clark, P.T. Madsen, C. Johnson, J. Kiszka, and O. Breysse. 2006. Observations of Longman's beaked whale (*Indopacetus pacificus*) in the western Indian Ocean. **Aquat. Mamm.** 32(2):223-231.

Anderwald, P., A. Brandecker, M. Coleman, C. Collins, H. Denniston, M.D. Haberlin, M. O'Donovan, R. Pinfield, F. Visser, and L. Walshe. 2013. Displacement responses of a mysticete, an odontocete, and a phocid seal to construction-related vessel traffic. **Endang. Species Res.** 21(3):231-240.

Arroyo, E. 2017. Mamíferos marinos de la Bahía de Banderas y aguas adyacentes: 1982-2015. Tesis de Licenciatura. UNAM. 89 p.

Arroyo E., M. Vázquez, S. Hernández, A. Aguayo, and L. Medrano, 2016. Mamíferos marinos de la Bahía de Banderas y aguas adyacentes: 1981-2015. xxxv Reunión Internacional para el Estudio de los Mamíferos Marinos. La Paz, B.C.S.

Atkinson, S., D. Crocker, D. Houser, and K. Mashburn. 2015. Stress physiology in marine mammals: How well do they fit the terrestrial model? **J. Comp. Physiol. B** 185(5):463-486.

Au, D.K.W. and W.L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. **Fish. Bull.** 83(4):623-643

Aurioles-Gamboa, D., F. Elorriaga-Verplancken, and C.J. Hernandez-Camacho. 2010. The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. **Mar. Mamm. Sci.** 26(2):402-408.

Azzara, A.J., W.M. von Zharen, and J.J. Newcomb. 2013. Mixed-methods analytic approach for determining potential impacts of vessel noise on sperm whale click behavior. **J. Acoust. Soc. Am.** 134(6):4566-4574.

Bain, D.E. and R. Williams. 2006. Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. **Int. Whal. Comm. Working Pap.** SC/58/E35. 13 p.

Baird, R.W. 2018a. Cuvier's beaked whale *Ziphius cavirostris*. p. 234-237 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Baird, R.W. 2018b. False killer whale *Pseudorca crassidens*. p. 347-349 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Baird, R.W. 2018c. Pygmy killer whale *Feresa attenuata*. p. 788-790 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Baker, C.S. and L.M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: experimental and opportunistic observations. NPS-NR-TRS-89-01. Rep. from Kewalo Basin Mar. Mamm. Lab., Univ. Hawaii, Honolulu, HI, for U.S. Natl. Park Serv., Anchorage, AK. 50 p. NTIS PB90-198409.

Baker, C.S., L.M. Herman, B.G. Bays, and W.F. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Natl. Mar. Fish. Serv., Seattle, WA. 78 p.

Baker, C.S., L.M. Herman, B.G. Bays, and G.B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Nat. Mar. Mamm. Lab., Seattle, WA. 30 p.

Ballance, L.T., R.L. Pitman, and P.C. Fiedler. 2006. Oceanographic influences on seabirds and cetaceans in the eatern tropical Pacific: a review. **Prog. Oceanogr.** 69:360-390.

Barkaszi, M.J. and C.J. Kelly. 2024. Analysis of protected species observer data: Strengths, weaknesses, and application in the assessment of marine mammal responses to seismic surveys in the northern Gulf of Mexico 2002–2015. **PloS ONE** 19(3):e0300658.

Barlow, J. and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. **J. Cetac. Res. Manage.** 7(3):239-249.

Barlow, J., M.C. Ferguson, W.F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, C.D. Macleod, K. Mullin, D.L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (familyZiphiidae). **J. Cetacean Res. Manage.** 7(3):263-270.

Barlow, J., M.C. Ferguson, E.A. Becker, J.V. Redfern, K.A. Forney, I.L. Vilchis, P.C. Fiedler, T. Gerrodette, L.T. Ballance. 2009. Predictive Modeling of Marine Mammal Density from existing survey data and model validation using upcoming surveys. SERDP Project SI-1391. Data downloaded October 31, 2024 from NOAA SWFSC Density Models available from the SERDP SDSS Marine Animal Model Mapper (released on November 19th, 2013) at https://seamap.env.duke.edu/serdp.

Barlow, J., J. Calambokidis, E.A. Falcone, C.S. Baker, A.M. Burdin, P.J. Clapham, J.K.B. Ford, and C.M. Gabriele. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. **Mar. Mamm. Sci. 27(4)**:793-818.

Barry, S.B., A.C. Cucknell, and N. Clark. 2012. A direct comparison of bottlenose dolphin and common dolphin behaviour during seismic surveys when airguns are and are not being utilised. p. 273-276 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Baumann-Pickering, S., M.A. Roch, R.L. Brownell, Jr., A.E. Simonis, M.A. McDonald, A. Solsona-Berga, E.M. Oleson, S.M. Wiggins, and J.A. Hildebrand. 2014. Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific. **PLoS One** 9(1):e86072.

Bayliff, W.H. (ed.) 2004. 2002 Annual report. Inter-American Tropical Tuna Commission, La Jolla, California. 96 p.

Belcher, R.L. and T.E. Lee, Jr. 2002. *Arctocephalus townsendi*. **Mamm. Species** 700:1-5.

Bernstein, L. 2013. The Washington Post: health, science, and environment. Panel links underwater mapping sonar to whale stranding for first time. Published 6 October 2013. Accessed in August 2021 at https://www.washingtonpost.com/national/health-science/panel-links-underwater-mapping-sonar-to-whale-stranding-for-first-time/2013/10/06/52510204-2e8e-11e3-bbed-a8a60c601153_story.html

Berzin, A.A. 1978. Whale distribution in tropical eastern Pacific waters. **Rep. Int. Whal. Comm.** 28:173-177.

Bettridge, S., C.S. Baker, J. Barlow, P.J. Clapham, M. Ford, D. Gouveia, D.K. Mattila, R.M. Pace, III, P.E. Rosel, G.K. Silber, and P.R. Wade. 2015. Status review of the humpback whale (Megaptera novaeangliae) under the Endangered Species Act. NOAA Tech. Memo. NMFS-SWFSC-540. Nat. Mar. Fish. Service, Southwest Fish. Sci. Center, La Jolla, CA. 240 p.

Bittencourt, L., I.M.S. Lima, L.G. Andrade, R.R. Carvalho, T.L. Bisi, J. Lailson-Brito, Jr., and A.F. Azevedo. 2017. Underwater noise in an impacted environment can affect Guiana dolphin communication. **Mar. Poll. Bull.** 114(2):1130-1134.

Blackwell, S.B., C.S. Nations, T.L. McDonald, C.R. Greene, Jr., A.M. Thode, M. Guerra, and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. **Mar. Mamm. Sci.** 29(4):E342-E365.

Blackwell, S.B., C.S. Nations, T.L. McDonald, A.M. Thode, D. Mathias, K.H. Kim, C.R. Greene, Jr., and A.M. Macrander. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. **PLoS ONE** 10(6):e0125720.

Blair, H.B., N.D. Merchant, A.S. Friedlaender, D.N. Wiley, and S.E. Parks. 2016. Evidence for ship noise impacts on humpback whale foraging behaviour. **Biol. Lett.** 12:20160005.

Block, B.A., I.D. Jonsen, S.J. Jorgensen, A.J. Winship, S.A. Shaffer, S.J. Bograd, E.L. Hazen, D.G. Foley, G.A. Breed, A.-L. Harrison, J.E. Ganong, A. Swithenbank, M. Castleton, H. Dewar, B.R. Mate, G.L. Shillinger, K.M. Schaefer, S.R. Benson, M.J. Weise, R.W. Henry, and D.P. Costa. 2011. Tracking apex marine predator movements in a dynamic ocean. **Nature** 475(7354):86-90.

Booth, C.G., R.R. Sinclair, and J. Harwood. 2020. Methods for monitoring for the population consequences of disturbance in marine mammals: a review. **Front. Mar. Sci.** 7:115.

Booth, C.G., N. Brannan, R. Dunlop, A. Friedlander, S. Isojunno, P. Miller, N. Quick, B. Southall, and E. Pirotta. 2022. A sampling, exposure and receptor framework for identifying factors that modulate behavioural responses to disturbance in cetaceans. **J. Animal Ecol.** 91(10):1948-1960.

Branch, T.A., D.M. Palacios, K.M. Stafford, C. Allison, J.L. Bannister, C.L.K. Burton, K.C.S. Jenner, M-N.M. Jenner, B. Maughan, T. Miyashita, M.G. Morrice, V.J. Sturrock, R.C. Anderson, A.N. Baker, P.B. Best, P. Borsa, S. Childerhouse, K.P. Findlay, A.D. Ilangakoon, M. Joergensen, B. Kahn, B. Maughan, Y.A. Mikhalev, Oman Whale and Dolphin Research Group, D. Thiele, D. Tormosov, K. Van Waerebeek, and R.M. Warneke. 2006. Past and present distribution of blue whales in the Southern Hemisphere and northern Indian Ocean. Paper SC/58/SH16 presented to the IWC Scientific Committee, June 2006 (unpublished). 27 p. Paper available from the IWC Secretariat: secretariat@iwcoffice.org.

Branch, T.A., D.P. Palacios, and C.C. Monnahan. 2016. Overview of North Pacific blue whale distribution, and the need for an assessment of the western and central Pacific. Paper SC/66b/IA 15 presented to the International Whaling Commission. 12 p.

Branstetter, B.K. and J.M. Sills. 2022. Mechanisms of auditory masking in marine mammals. **Animal Cogn.** 25(5):1029-1047.

Branstetter, B.K., J.S. Trickey, H. Aihara, J.J. Finneran, and T.R. Liberman. 2013. Time and frequency metrics related to auditory masking of a 10 kHz tone in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 134(6):4556-4565.

Branstetter, B.K., K.L. Bakhtiari, J.S. Trickey, and J.J. Finneran. 2016. Hearing mechanisms and noise metrics related to auditory masking in bottlenose dolphins (*Tursiops truncatus*). p. 109-116 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Breitzke, M. and T. Bohlen. 2010. Modelling sound propagation in the Southern Ocean to estimate the acoustic impact of seismic research surveys on marine mammals. **Geophys. J. Int.** 181(2):818-846.

Bröker, K. 2019. An overview of potential impacts of hydrocarbon exploration and production on marine mammals and associated monitoring and mitigation measures. **Aquatic Mammals.** 45(6):576-611.

Bröker, K., J. Durinck, C. Vanman, and B. Martin. 2013. Monitoring of marine mammals and the sound scape during a seismic survey in two license blocks in the Baffin Bay, West Greenland, in 2012. p. 32 *In*: Abstr. 20th Bienn. Conf. Biol. Mar. Mamm., 9–13 December 2013, Dunedin, New Zealand. 233 p.

Bröker, K., G. Gailey, J. Muir, and R. Racca. 2015. Monitoring and impact mitigation during a 4D seismic survey near a population of gray whales off Sakhalin Island, Russia. **Endang. Species Res.** 28:187-208.

Brown, A., K.D. Seger, M.P. Rey-Baquero, and L.V. Huertas-Amaya. 2023. Frequencies of humpback whale song units (*Megaptera novaeangliae*): Adjustments to small boat noise. *In:* A.N. Popper, J. Sisneros, A.D. Hawkins, and F. Thomsen (eds.) The Effects of Noise on Aquatic Life. Springer Nature, Switzerland. 500 p.

Buchanan, J.B., D.H. Johnson, E.L. Greda, G.A. Green, T.R. Wahl, and S.J. Jeffries. 2001. Wildlife of coastal and marine habitats. p. 389-422 *In*: D.H. Johnson and T.A. O'Neil (eds.), Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press.

Burnham, R. 2023. Acoustic disturbance risk estimates and mitigation strategies: an animal-centric approach. *In:* A.N. Popper, J. Sisneros, A.D. Hawkins, and F. Thomsen (eds.) The Effects of Noise on Aquatic Life. Springer Nature, Switzerland. 500 p. Available at https://doi.org/10.1007/978-3-031-10417-6_190-1

Buscaino, G., M. Ceraulo, V.M., Giacalone, E. Papale, M. Gregorietti, S. Mazzola, R. Grammauta, M.P. Sal Moyano, V. Di Fiore, M. Dioguardi, and M. Mauro. 2019. Effects of water gun on echinoderms: biochemical changes on sea Urchin (*Arbacia lixula*) and sea Cucumber (*Holothuria tubulosa*). Poster presentation at the 5th International Conference on the Effects of Noise on Aquatic Life, Den Haag, Netherlands.

Busquets-Vass, G., S.D. Newsome, M.A. Pardo, J. Calambokidis, S. Aguíñiga-García, D. Páez-Rosas, J. Gómez-Gutiérrez, L.M. Enríquez-Paredes, and D. Gendron. 2021. Isotope-based inferences of the seasonal foraging and migratory strategies of blue whales in the eastern Pacific Ocean. **Mar. Environ. Res.** 163:105201.

Calambokidis, J., G.H Steiger, K. Rasmussen, J. Urbán R., K.C. Balcomb, P. Ladrón De Guevara, M. Salinas Z., J.K. Jacobsen, C.S. Baker, L.M. Herman, S. Cerchio, and J.D. Darling. 2000. Migratory destinations of humpback whales from the California, Oregon and Washington feeding ground. **Mar. Ecol. Prog. Ser.** 192:295-304.

Calambokidis, J., G.H. Steiger, J.M. Straley, L.M. Herman, S. Cerchio, D.R. Salden, J. Urbán R., J.K. Jacobsen, O. von Ziegesar, K.C. Balcomb, C.M. Gabrielle, M.E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P.L. de Guevara, M. Yamaguchi, F. Sato, S.A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T.J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. **Mar. Mamm. Sci.** 17(4):769-794.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: structure of populations, levels of abundance and status of humpback whales in the North Pacific. Rep. AB133F-03-RP-0078 for U.S. Dept. of Comm., Seattle, WA.

Campana, I., R. Crosti, D. Angeletti, L. Carosso, L. Davis, N. Di-Méglio, A. Moulins, M. Rosso, P. Tepsich, and A. Arcangeli. 2015. Cetacean response to summer maritime traffic in the western Mediterranean Sea. **Mar. Environ. Res.** 109:1-8.

Carome, W., E. Slooten, W. Rayment, T. Webster, L. Wickman, T. Brough, and S.M. Dawson. 2022. A long-term shift in the summer distribution of Hector's dolphins is correlated with an increase in cruise ship tourism. **Aquatic Conserv. Mar. Freshw. Ecosyst.** 32(10):1660-1674.

Carretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker B. Hanson, A.J. Orr, J. Barlow, J. Moore, and R.L. Brownwell, Jr. 2021. U.S. Pacific marine mammal stock assessments: 2020. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-646. Nat. Mar. Fish. Serv., Southwest Fish. Sci. Center, La Jolla, CA. 389 p.

Castellote, M. and C. Llorens. 2016. Review of the effects of offshore seismic surveys in cetaceans: Are mass strandings a possibility? p. 133-143 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Castellote, M., C.W. Clark, and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. **Biol. Conserv.** 147(1):115-122.

Castellote, M., M. Stocker, and A. Brewer. 2020. Passive acoustic monitoring of cetaceans & noise during Hilcorp 3D seismic survey in Lower Cook Inlet, AK. Final report – October 2020. Submitted to Hilcorp, BOEM, and NMFS. 23 p.

Celi, M., F. Filiciotto, D. Parrinello, G. Buscaino, M.A. Damiano, A. Cuttitta, S. D'Angelo, S. Mazzola, and M. Vazzana. 2013. Physiological and agonistic behavioural response of *Procambarus clarkii* to an acoustic stimulus. **J. Exp. Biol.** 216(4):709-718.

Cerchio, S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. **PLoS ONE** 9(3):e86464. doi:10.1371/journal.pone.0086464.

Cholewiak, D., A. Izzi, D. Palka, P. Corkeron, and S. Van Parijs. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. Abstract and presentation at the Society for Marine Mammalogy's 22nd Biennial Conference on the Biology of Marine Mammals, 22–27 October, Halifax, NS, Canada.

Cholewiak, D., C.W. Clark, D. Ponirakis, A. Frankel, L.T. Hatch, D. Risch, J.E. Stanistreet, M. Thompson, E. Vu, and S.M. Van Parijs. 2018. Communicating amidst the noise: modeling the aggregate influence of ambient and vessel noise on baleen whale communication space in a national marine sanctuary. **Endang. Species Res**. 36:59-75.

Clapham, P.J. 2018. Humpback whale *Megaptera novaeangliae*. p. 489-492 *In*: B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Clapham, P.J. and J.G. Mead. 1999. *Megaptera novaeangliae*. **Mamm. Spec.** 604:1-9.

Clark, C.W. and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. Working Pap. SC/58/E9. Int. Whal. Comm., Cambridge, UK. 9 p.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. **Mar. Ecol. Prog. Ser.** 395:201-222.

Clarke, R. 1980. Catches of sperm whales and whalebone whales in the southeast Pacific between 1908 and 1975. **Rep. Int. Whal. Comm.** 30:285-288.

Cones, S.F., Y. Jézéquel, and T.A. Mooney. 2023. Marine bivalve sound detection and associated noise impacts. *In*: A.N. Popper, J. Sidneros, A.D. Hawkins, and F. Thomesen (eds.), The Effects of Noise on Aquatic Life: Principles and Practical Considerations. Springer, Cham. https://doi.org/10.1007/978-3-031-10417-6_32-1.

Corrigan, S., A.D. Lowther, L.B. Beheregaray, B.D. Bruce, G. Cliff, C.A. Duffy, A. Foulis, M.P. Francis, S.D. Goldsworthy, J.R. Hyde, R.W. Jabado, D. Kacev, L. Marshall, G.R. Mucientes, G.J.P. Naylor, J.G. Pepperell, N. Queiroz, W.T. White, S.P. Wintner, and P.J. Rogers. 2018. Population connectivity of the highly migratory shortfin mako (Isurus oxyrinchus Rafinesque 1810) and implications for management in the Southern Hemisphere. **Front. Ecol. Evol.** 6:1-15.

Costa, D.P. and T.M. Williams. 1999. Marine mammal energetics. p. 176-217 *In:* J.E. Reynolds III and S.A. Rommel (eds.), Biology of marine mammals. Smithsonian Institution Press, Washington. 578 p.

Costa, D.P., L. Schwarz, P. Robinson, R. Schick, P.A. Morris, R. Condit, D.E. Crocker, and A.M. Kilpatrick. 2016a. A bioenergetics approach to understanding the population consequences of disturbance: elephant seals as a model system. p. 161-169 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Costa, D.P., L.A. Huckstadt, L.K. Schwarz, A.S. Friedlaender, B.R. Mate, A.N. Zerbini, A. Kennedy, and N.J. Gales. 2016b. Assessing the exposure of animals to acoustic disturbance: towards an understanding of the population consequences of disturbance. Proceedings of Meetings on Acoustics 4ENAL 27(1):010027.

Cramer, K.L., W.L. Perryman, W.L., and T. Gerrodette. 2008. Declines in reproductive output in two dolphin populations depleted by the yellowfin tuna purse-seine fishery. **Mar. Ecol. Progr. Ser.** 369:273-285.

Culloch, R.M., P. Anderwald, A. Brandecker, D. Haberlin, B. McGovern, R. Pinfield, F. Visser, M. Jessopp, and M. Cronin. 2016. Effect of construction-related activities and vessel traffic on marine mammals. **Mar. Ecol. Prog. Ser.** 549:231-242.

Currie, J.J., S.H. Stack, and G.D. Kaufman. 2017. Modelling whale-vessel encounters: the role of speed in mitigating collisions with humpback whales (*Megaptera novaeangliae*). **J. Cetacean Res. Manage.** 17(1):57-63.

Dahlheim, M. and M. Castellote. 2016. Changes in the acoustic behavior of gray whales *Eschrichtius robustus* in response to noise. **Endang. Species Res.** 31:227-242.

Dahlheim, M.E., S. Leatherwood, and W.F. Perrin. 1982. Distribution of killer whales in the warm temperate and tropical eastern Pacific. **Rep. Int. Whal. Comm.** 32:647-653.

Dalebout, M.L., C.S. Baker, D. Steel, K. Thompson, K.M. Robertson, S.J. Chivers, W.F. Perrin, M. Gonnatilake, R.C. Anderson, J.G. Mead, C.W. Potter, L. Thompson, D. Jupiter, and T.K. Yamada. 2014. Resurrection of *Mesoplodon hotaula* Deraniyagala 1963: a new species of beaked whale in the tropical Indo-Pacific. **Mar. Mamm. Sci.** 30(3):1081-1108.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. **Mar. Mamm. Sci.** 14(3):490-507.

Debrot, A.O. 1998. New cetacean records for Curaçao, Netherlands Antilles. **Caribbean J. Sci.** 34(1-2):168-169.

Deng, Z.D., B.L. Southall, T.J. Carlson, J. Xu, J.J. Martinez, M.A. Weiland, and J.M. Ingraham. 2014. 200-kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. **PLoS ONE** 9(4):e95315. doi:10.1371/journal.pone.0095315.

Di Iorio, L. and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. **Biol. Lett.** 6(1):51-54.

Dive Advisor. 2024. Advice on Scuba Diving in Pacific Ocean Coast, Mexico. Accessed October 2024 at https://diveadvisor.com/mexico/pacific-ocean-coast-scuba-diving

Dizon, A.E., S.O. Southern, and W.F. Perrin. 1991. Molecular analysis of mtDNA types in exploited populations of spinner dolphins (*Stenella longirostris*). **Rep. Int. Whal. Comm. Spec. Iss.** 13:183-202.

Dolar, M.L.L. 2018. Fraser's dolphin *Lagenodelphis hosei*. p. 392-395 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Dolman, S.J., and M. Jasny. 2015. Evolution of marine noise pollution management. **Aquat. Mammal.** 41(4):357-374.

DoN. 2017a. Criteria and thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Technical report prepared by the U.S. Navy.

DoN. 2017b. U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. 274 p.

DoN. 2019. U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. 262 p.

Donovan, G.P. 1984. Blue whales off Peru, December 1982, with special reference to pygmy blue whales. **Rep. Int. Whal. Comm.** 34:473-476.

Donovan, G.P. 1991. A review of IWC stock boundaries. **Rep. Int. Whal. Comm. Spec. Iss.** 13:39-63.

Donovan, C.R., C.M. Harris, L. Milazzo, J. Harwood, L. Marshall, and R. Williams. 2017. A simulation approach to assessing environmental risk of sound exposure to marine mammals. **Ecol. Evol.** 7:2101-2111.

Douglas, A.B., F.G. Alpízar, A. Acevedo-Gutiérrez, S.D. Mahaffy, K. Rasmussen, E. Quintana-Rizzo, J. De Weerdt, D.M. Palacios, D. Martínez-Fernández, C. Lazcano-Pacheco, and C.D.O. Ortiz. 2023. False killer whales (*Pseudorca crassidens* Cetacea: Delphinidae) along the Pacific coast of Central America and Mexico: Long-term movements, association patterns and assessment of fishery interactions. **Rev. Biol. Trop.** 71(S4):e57189-e57189.

Duffield, D.A., S.H. Ridgway, and L.H. Cornell. 1983. Hematology distinguishes coastal and offshore forms of dolphins (*Tursiops*). **Can. J. Zool.** 61(4):930-933.

Dunlop, R.A. 2015. The effect of vessel noise on humpback whale, *Megaptera novaeangliae*, communication behaviour. **Animal Behav.** 111:13-21.

Dunlop, R. 2018. The communication space of humpback whale social sounds in vessel noise. **Proceedings of Meetings on Acousti**cs 35(1):010001.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, D. Paton, and D.H. Cato. 2015. The behavioural response of humpback whales (*Megaptera novaeangliae*) to a 20 cubic inch air gun. **Aquatic Mamm.** 41(4):412-433.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2016a. Response of humpback whales (*Megaptera novaeangliae*) to ramp-up of a small experimental air gun array. **Mar. Poll. Bull.** 103:72-83.

Dunlop, R.A., M.J. Noad, and D.H. Cato. 2016b. A spatially explicit model of the movement of humpback whales relative to a source. Proceedings of Meetings on Acoustics 4ENAL 27(1):010026. doi:10.1121/2.0000296.

Dunlop, R., M.J. Noad, R. McCauley, and D. Cato. 2016c. The behavioral response of humpback whales to seismic air gun noise. **J. Acoust. Soc. Am.** 140(4):3412.

Dunlop, R.A., M.J. Noad, R.D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2017a. Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. **J. Exp. Biol.** 220:2878-2886.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2017b. The behavioural response of migrating humpback whales to a full seismic airgun array. **Proc. R. Soc. B** 284:20171901.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2018. A behavioural dose-response model for migrating humpback whales and seismic air gun noise. **Mar. Poll. Bull.** 133:506-516.

Dunlop, R.A., R.D. McCauley, and M.J. Noad. 2020. Ships and air guns reduce social interactions in humpback whales at greater ranges than other behavioral impacts. **Mar. Poll. Bull.** 154:111072.

Dunlop, R.A., J. Braithwaite, L.O. Mortensen, and C.M. Harris. 2021. Assessing population-level effects of anthropogenic disturbance on a marine mammal population. **Front. Mar. Sci.** 8:624981.

Dyndo, M., D.M. Wisniewska, L. Rojano-Doñate, and P.T. Madsen. 2015. Harbour porpoises react to low levels of high frequency vessel noise. **Sci. Rep.** 5:11083. http://dx.doi.org/doi:10.1038/srep11083.

Edmonds, N.J., C.J. Firmin, D. Goldsmith, R.C. Faulkner, and D.T. Wood. 2016. A review of crustacean sensitivity to high amplitude underwater noise: data needs for effective risk assessment in relation to UK commercial species. **Mar. Poll. Bull.** 108 (1-2):5-11.

Edwards, E.F., C. Hall, T.J. Moore, C. Sheredy, and J.V. Redfern. 2015. Global distribution of fin whales *Balaenoptera physalus* in the post-whaling era (1980–2012). **Mamm. Rev.** 45(4):197-214.

Ellison, W.T., B.L. Southall, C.W. Clark, and A.S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. **Conserv. Biol.** 26(1):21-28.

Ellison, W.T., R. Racca, C.W. Clark, B. Streever, A.S. Frankel, E. Fleishman, R. Angliss, J. Berger, D. Ketten, M. Guerra, M. Leu, M. McKenna, T. Sformo, B. Southall, R. Suydam, and L. Thomas. 2016. Modeling the aggregated exposure and responses of bowhead whales *Balaena mysticetus* to multiple sources of anthropogenic underwater sound. **Endang. Species Res.** 30:95-108.

Ellison, W.T., B.L. Southall, A.S. Frankel, K. Vigness-Raposa, and C.W. Clark. 2018. An acoustic scene perspective on spatial, temporal, and spectral aspects of marine mammal behavioral responses to noise. **Aquat. Mamm**. 44(3):239-243.

Elorriaga-Verplancken, F.R., C.J. Hernández-Camacho, L. Álvarez-Santamaría, A. Paniagua-Mendoza, R. Robles-Hernández, F. Rebolledo-Villa, H. Rosales-Nanduca, A. Ramos-Rodríguez, and K. Acevedo-Whitehouse. 2022. Largest mortality event to date of California sea lions in Mexico might be linked to a harmful algal bloom. **Aquatic Mamm.** 48(1):59-67.

Engel, M.H., M.C.C. Marcondes, C.C.A. Martins, F.O. Luna, R.P. Lima, and A. Campos. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Working Paper SC/56/E28. Int. Whal. Comm., Cambridge, UK. 8 p.

Erbe, C. 2012. The effects of underwater noise on marine mammals. p. 17-22 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: a review and research strategy. **Mar. Poll. Bull.** 103:15-38.

Erbe, C., S.A. Marley, R.P. Schoeman, J.N. Smith, L.E. Trigg, and C.B. Embling. 2019. The effects of ship noise on marine mammals—a review. **Front. Mar. Sci.** 6:606.

Erbe, C., M.L. Dent, W.L. Gannon, R.D. McCauley, H. Römer, B.L. Southall, A.L. Stansbury, A.S. Stoeger, and J.A. Thomas. R. Schoeman, D. Peel and J.N. Smith. 2022. The effects of noise on aimals. p. 459-506 *In:* C. Erbe and J. A. Thomas (eds.) Exploring Animal Behavior Through Sound: Volume 1. Springer Nature Switzerland AG.

Escorza-Treviño, S. 2009. North Pacific marine mammals. p. 781-788 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2nd edit. Academic Press, San Diego, CA. 1316 p.

Escorza-Treviño, S., F.I. Archer, M. Rosales, A. Lang, and A.E. Dizon. 2005. Genetic differentiation and intraspecific structure of Eastern Tropical Pacific spotted dolphins, *Stenella attenuata*, revealed by DNA analyses. **Conserv. Genetics** 6(4):587-600.

Evans, P.G.H. 1987. The natural history of whales and dolphins. Christopher Helm, Bromley, Kent. 343 p.

Farmer, N., K. Baker, D. Zeddies, M. Zykov, D. Noren, L. Garrison, E. Fougeres, and A. Machernis. 2017. Population consequences of disturbance for endangered sperm whales (*Physeter macrocephalus*) exposed to seismic surveys in the Gulf of Mexico, USA. Abstract and presentation at the Society for Marine Mammalogy's 22nd Biennial Conference on the Biology of Marine Mammals, 22–27 October, Halifax, NS, Canada.

Ferguson, M.C. and J. Barlow. 2001. Spatial distribution and density of cetaceans in the Eastern Tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Admin. Rep. LJ-01-04, SWFSC, NMFS, La Jolla, CA. 61 p.

Ferguson, M.C., J. Barlow, S.B. Reilly, and T. Gerrodette. 2006. Predicting Cuvier's (*Ziphiuscavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the Eastern Tropical Pacific Ocean. **J. Cetacean Res. Manage.** 7(3): 287-299

Fernandez-Betelu, O., I.M. Graham, K.L. Brookes, B.J. Cheney, T.R. Barton, and P.M. Thompson. 2021. Far-field effects of impulsive noise on coastal bottlenose dolphins. **Frontiers Mar. Sci.** 8:664230.

Ferrero, R.C., R.C. Hobbs, and G.R. VanBlaricom. 2002. Indications of habitat use patterns among small cetaceans in the central North Pacific based on fisheries observer data. **J. Cetac. Res. Manage.** 4:311-321.

Fiedler, P.C. 2002. The annual cycle and biological effects of the Costa Rica Dome. **Deep-Sea Res. I** 49:321-338.

Finneran, J.J. 2012. Auditory effects of underwater noise in odontocetes. p. 197-202 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Finneran, J.J. 2015. Noise-induced hearing loss in marine mammals: a review of temporary threshold shift studies from 1996 to 2015. **J. Acoust. Soc. Am.** 138(3):1702-1726.

Finneran, J.J. 2020. Conditional attenuation of dolphin monaural and binaural auditory evoked potentials after preferential stimulation of one ear. **J. Acoust. Soc. Am.** 147(4):2302-2313.

Finneran, J.J. and B.K. Branstetter. 2013. Effects of noise on sound perception in marine mammals. p. 273-308 *In*: H. Brumm (ed.), Animal communication and noise. Springer Berlin, Heidelberg, Germany. 453 p.

Finneran, J.J. and C.E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (*Tursiops truncatus*) (L). **J. Acoust. Soc. Am.** 128(2):567-570.

Finneran, J.J. and C.E. Schlundt. 2011. Noise-induced temporary threshold shift in marine mammals. **J. Acoust. Soc. Am.** 129(4):2432. [Supplemented by oral presentation at the ASA meeting, Seattle, WA, May 2011].

Finneran, J.J. and C.E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 133(3):1819-1826.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and beluga whales (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. **J. Acoust. Soc. Am.** 108(1):417-431.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. **J. Acoust. Soc. Am.** 111(6):2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. **J. Acoust. Soc. Am.** 118(4):2696-2705.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010a. Growth and recovery of temporary threshold shift (TTS) at 3 kHz in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 127(5):3256-3266.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010b. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. **J. Acoust. Soc. Am.** 127(5):3267-3272

Finneran, J.J., C.E. Schlundt, B.K. Branstetter, J.S. Trickey, V. Bowman, and K. Jenkins. 2015. Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. **J. Acoust. Soc. Am.** 137(4):1634-1646.

Finneran, J.J., C.E. Schlundt, and J. Mulsow. 2023a. Temporary threshold shift in bottlenose dolphins exposed to steady-state, 1/6-octave noise centered at 0.5 to 80 kHz. **J. Acoust. Soc. Am.** 154:1342-1338.

Finneran, J.J., C.E. Schlundt, V. Bowman, and K. Jenkins. 2023b. Dolphins reduce hearing sensitivity in anticipation of repetitive impulsive noise exposures. **J. Acoust. Soc. Am.** 153(6):3372-3372.

Finneran, J.J., K. Lally, M.G. Strahan, K. Donohoe, J. Mulsow, and D.S. Houser. 2023c. Dolphin conditioned hearing attenuation in response to repetitive tones with increasing level. **J. Acoust. Soc. Am.** 153(1):496-504.

Finneran, J.J., Lally, K., Mulsow, J. and Houser, D.S., 2024. Dolphin short-term auditory fatigue and self-mitigation. **J. Acoust. Soc. Am.** 155(3):.2241-2246.

Ford, J.K.B. 2018. Killer whale *Orcinus orca*. p. 531-537 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Fornet, M.E.H., L.P. Matthews, C.M. Gabriele, S. Haver, D.K. Mellinger, and H. Klinck. 2018. Humpback whales *Megaptera novaeangliae* alter calling behavior in response to natural sounds and vessel noise. **Mar. Ecol. Prog. Ser.** 607:251-268.

Forney, K.A. and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991–1992. **Mar. Mamm. Sci.** 14 (3):460-489.

Forney, K.A., M.C. Ferguson, E.A. Becker, P.C. Fiedler, J.V. Redfern, J. Barlow, I.L. Vilchis, and L.T. Balance. 2012. Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. **Endang. Spec. Res.** 16(2):113-133.

Forney, K.A., B.L. Southall, E. Slooten, S. Dawson, A.J. Read, R.W. Baird, and R.L. Brownell, Jr. 2017. Nowhere to go: noise impact assessments for marine mammal populations with high site fidelity. **Endang. Species Res.** 32:391-413.

Frankel, A.S. and P.J. Stein. 2020. Gray whales hear and respond to signals from a 21–25 kHz active sonar. **Mar. Mamm. Sci.** 26(4):1111-1125.

Frisch-Jordan, A., N.L. Ransome, O. Aranda-Mena, and F. Romo-Sirvent. 2019. Intensive feeding of humpback whale (*Megaptera novaeangliae*) in the breeding ground of Banderas Bay, Mexico**. Latin Am. J. Aquatic Mamm.** 14(1):27-33

Frisch-Jordán, A. and D.C. López-Arzate. 2024. Large whale entanglements in Mexico, a 25-year review from 1996 to 2021. **Mar. Mamm. Sci. (**2024):e13106.

Gailey, G., B. Würsig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):75-91.

Gailey, G., O. Sychenko, T. McDonald, R. Racca, A. Rutenko, and K. Bröker. 2016. Behavioural responses of western gray whales to a 4-D seismic survey off northeastern Sakhalin Island, Russia. **Endang. Species Res.** 30:53-71.

Gailey, G., O. Sychenko, A. Rutenko, and R. Racca. 2017. Western gray whale behavioral response to extensive seismic surveys conducted near their feeding grounds. Abstract and presentation at the Society for Marine Mammalogy's 22nd Biennial Conference on the Biology of Marine Mammals, 22–27 October, Halifax, NS, Canada.

Gailey, G., M. Zykov, O. Sychenko, A. Rutenko, A.L. Blanchard, L Aerts, and R.H. Melton. 2022a. Gray whale density during seismic surveys near their Sakhalin feeding ground. **Env. Monit. Assess.** 194 (Suppl. 1):739. https://doi.org/10.1007/s10661-022-10025-8.

Gailey, G., M. Zykov, O. Sychenko, A. Rutenko, A.L. Blanchard, L Aerts, and R.H. Melton. 2022b. Western gray whale behavioral response to seismic surveys during their foraging season. **Env. Monit. Assess.** 194 (Suppl. 1):740. https://doi.org/10.1007/s10661-022-10023-w.

Gallagher, C.A., V. Grimm, L.A. Kyhn, C.C. Kinze, and J. Nabe-Nielsen. 2021. Movement and seasonal energetics mediate vulnerability to disturbance in marine mammal populations. **Am. Nat.** 197(3):296-311.

Gallo-Reynoso, J.P. and J.L. Solórzano-Velasco. 1991. Two new sightings of California sea lions on the southern coast of México. **Mar. Mamm. Sci**. 7:96.

Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). p. 171-192 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The sirenians and baleen whales. Academic Press, London, UK. 362 p.

Gannier, A. 2000. Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. **Aquat. Mamm.** 26(2):111-126.

Gannier, A. and J. Epinat. 2008. Cuvier's beaked whale distribution in the Mediterranean Sea: results from small boat surveys 1996–2007. **J. Mar. Biol. Assoc. U.K.** 88(6):1245-1251.

Gannier, A.J., G. Boyer, and A.C. Gannier. 2022. Recreational boating as a potential stressor of coastal striped dolphins in the northwestern Mediterranean Sea. **Mar. Poll. Bull.** 185:114222.

Garrigue, C., A. Aguayo, V.L.U. Amante-Helweg, C.S. Baker, S. Caballero, P. Clapham, R. Constantine, J. Denkinger, M. Donoghue, L. Flórez-González, J. Greaves, N. Hauser, C. Olavarría, C. Pairoa, H. Peckham, and M. Poole. 2002. Movements of humpback whales in Oceania, South Pacific. **J. Cetac. Res. Manage.** 4(3):255-260.

Garrigue, C., P.J. Clapham, Y. Geyer, A.S. Kennedy, and A.N. Zerbini. 2015. Satellite tracking reveals novel migratory patterns and the importance of seamounts for endangered South Pacific humpback whales. **R. Soc. Open Sci.** 2:150489.

Gedamke, J. 2011. Ocean basin scale loss of whale communication space: potential impacts of a distant seismic survey. p. 105-106 *In*: Abstr. 19th Bienn. Conf. Biol. Mar. Mamm., 27 Nov.–2 Dec. 2011, Tampa, FL. 344 p.

Gerrodette, T. and J. Forcada. 2002. Estimates of abundance of western/southern spotted, whitebelly spinner, striped and common dolphins, and pilot, sperm and bryde's whales in the Eastern Tropical Pacific Ocean. SWFSC Admin. Rep LJ-02-20. 24 p.

Gerrodette, T. and J. Forcada. 2005. Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. **Mar. Ecol. Prog. Ser.** 291:1-21.

Gerrodette, T. and D.M. Palacios. 1996. Estimates of cetacean abundance in EEZ waters of the Eastern Tropical Pacific. NMFS, SWFSC, Admin. Rep. JL-96-10, 27 p.

Gerrodette, T., G. Watters, and J. Forcada. 2005. Preliminary estimates of 2003 dolphin abundance in the Eastern Tropical Pacific. NMFS, SWFSC, Admin. Rep. JL-05-10-05. 26 p.

Gerrodette T., G. Watters, W. Perryman, and L. Ballance. 2008. Estimates of 2006 dolphin abundance on the Eastern Tropical Pacific, with revised estimates from 1986-2003. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-422. Southwest Fisheries Science Center, La Jolla, California, US. 43 p.

Gervaise, C., N. Roy, Y. Simard, B. Kinda, and N. Menard. 2012. Shipping noise in whale habitat: characteristics, sources, budget, and impact on belugas in Saguenay-St. Lawrence Marine Park hub. **J. Acoust. Soc. Am.** 132(1):76-89.

Gomez, C., J.W. Lawson, A.J. Wright, A.D. Buren, D. Tollit, and V. Lesage. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. **Can. J. Zool.** 94(12):801-819.

González, L.M., H.R. Nanduca, M. de Jesús Vázquez, J.U.R. Cuevas, L.R. Bracho, M.A. Salinas, L.F.B.M. Zacarías, L.V. Gómora, E.M.P. Recagno, and A.A. Lobo. 2008. Diversidad, composiciones comunitarias y estructuras poblacionales de la mastofauna marina en el pacífico mexicano y aguas circundantes. p. 469-492 *In:* Avances en el Estudio de los Mamíferos de México. Publicaciones Especiales, Vol. II, Asociación Mexicana de Mastozoología, A. C., México, D. F.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift, and D. Thompson. 2004. A review of the effects of seismic surveys on marine mammals. **Mar. Technol. Soc. J.** 37(4):16-34.

Gospić, N.R. and M. Picciulin. 2016. Changes in whistle structure of resident bottlenose dolphins in relation to underwater noise and boat traffic. **Mar. Poll. Bull.** 105:193-198.

Gransier, R. and R.A. Kastelein. 2024. Similar susceptibility to temporary hearing threshold shifts despite different audiograms in harbor porpoises and harbor seals. **J. Acoust. Soc. Am.** 155(1):396-404.

Gray, H. and K. Van Waerebeek. 2011. Postural instability and akinesia in a pantropical spotted dolphin, *Stenella attenuata*, in proximity to operating airguns of a geophysical seismic vessel. **J. Nature Conserv.** 19(6):363-367.

Gregr, E.J. and A.W. Trites. 2001. Predictions of critical habitat of five whale species in the waters of coastal British Columbia. **Can. J. Fish. Aquat. Sci.** 58(7):1265-1285.

Gridley, T., S.H. Elwen, G. Rashley, A.B. Krakauer, and J. Heiler. 2016. Bottlenose dolphins change their whistling characteristics in relation to vessel presence, surface behavior and group composition. **Proceedings of Meetings on Acoustics 4ENAL** 27(1):010030.

Groenewoud, Z. 2023. Communicating in noisy waters: assessing the impact of shipping activity on blue and fin whale calling activity in the Santa Barbara Channel during Covid-19. MSc. Thesis. Norwegian University of Science and Technology, Norway.

Guan, S., J.F. Vignola, J.A. Judge, D. Turo, and T.J. Ryan. 2015. Inter-pulse noise field during an arctic shallow-water seismic survey. **J. Acoust. Soc. Am.** 137(4):2212.

Guerra, M., A.M. Thode, S.B. Blackwell, and M. Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. **J. Acoust. Soc. Am.** 130(5):3046-3058.

Guerra, M., P.J. Dugan, D.W. Ponirakis, M. Popescu, Y. Shiu, and C.W. Clark. 2016. High-resolution analysis of seismic airgun impulses and their reverberant field as contributors to an acoustic environment. p. 371-379 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Guerrero, M., J. Urbán, and L. Rojas. 2006. Las ballenas del Golfo de California. SEMARNAT-INE, México, 524 p.

Hain, J.H.W., W.A.M. Hyman, R.D. Kenney, and H.E. Winn. 1985. The role of cetaceans in the shelf-edge region of the U.S. **Mar. Fish. Rev.** 47(1):13-17.

Hall, M.A. 1998. An ecological view of the tuna-dolphin problem: impacts and trade-offs. **Rev. Fish Biol.** 8(1):1-34.

Hall, M.A. and S.D. Boyer. 1989. Estimates of incidental mortality of dolphins in the eastern Pacific fishery for tropical tunas in 1987. **Rep. Int. Whal. Comm.** 39:321-322.

Halliday, W.D., S.J. Insley, R.C. Hilliard, T. de Jong, and M.K. Pine. 2017. Potential impacts of shipping noise on marine mammals in the western Canadian Arctic. **Mar. Poll. Bull.** 123:73–82.

Hansen, L.J., K.D. Mullin, and C.L. Roden. 1994. Preliminary estimates of cetacean abundance in the U.S. Atlantic Exclusive Economic Zone from 1992 vessel surveys. Southeast Fisheries Science Center, Miami Laboratory. Contribution No. MIA-93/94-58.

Harris, C.M., L. Thomas, E.A. Falcone, J. Hildebrand, D. Houser, P.H. Kvadsheim, F.-P.A. Lam, P.J.O. Miller, D.J. Moretti, A.J. Read, H. Slabbekoorn, B.L. Southall, P.L. Tyack, D. Wartzok, and V.M. Janik. 2017. Marine mammals and sonar: dose–response studies, the risk-disturbance hypothesis and the role of exposure context. **J. Appl. Ecol.** http://dx.doi.org/doi:10.1111/1365-25664.12955.

Hartman, K.L. 2018. Risso's dolphin *Grampus griseus*. p. 824-827 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Harwood, J. and B. Wilson. 2001. The implications of developments on the Atlantic Frontier for marine mammals. **Cont. Shelf Res.** 21(8-10):1073-1093.

Harwood, J., S. King, C. Booth, C. Donovan, R.S. Schick, L. Thomas, and L. New. 2016. Understanding the population consequences of acoustic disturbance for marine mammals. **Adv. Exp. Med. Biol.** 875:417-243.

Hastie, G.D., C. Donovan, T. Götz, and V.M. Janik. 2014. Behavioral responses of grey seals (*Halichoerus grypus*) to high frequency sonar. **Mar. Poll. Bull.** 79(1-2):205-210.

Hastie, G., N.D. Merchant, T. Götz, D.J. Russell, P. Thompson, and V.M. Janik. 2019. Effects of impulsive noise on marine mammals: investigating range-dependent risk. **Ecol. Appl.** 15:e01906.

Hastie, G.D., P. Lepper, J.C. McKnight, R. Milne, D.J. Russell, and D. Thompson. 2021. Acoustic risk balancing by marine mammals: anthropogenic noise can influence the foraging decisions by seals. **J. Appl. Ecol.** 58(9):1854-1863.

Hatch, L.T., C.W. Clark, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. **Conserv. Biol.** 26(6):983-994.

Heckel, G., M.G. Ruiz Mar, Y. Schramm, and U. Gorter. 2020. Atlas of marine mammal distribution and abundance in Mexican waters. Universidad Autónoma de Campeche. 186 p.

Heide-Jørgensen, M.P., R.G. Hansen, S. Fossette, N.J. Nielsen, M.V. Jensen, and P. Hegelund. 2013a. Monitoring abundance and hunting of narwhals in Melville Bay during seismic surveys. September 2013. Greenland Institute of Natural Resources. 56 p.

Heide-Jørgensen, M.P., R.G. Hansen, K. Westdal, R.R. Reeves, and A. Mosbech. 2013b. Narwhals and seismic exploration: Is seismic noise increasing the risk of ice entrapments? **Biol. Conserv.** 158:50-54.

Heide-Jørgensen, M.P., S.B. Blackwell, O.M. Tervo, A.L. Samson, E. Garde, R.G. Hansen, M.C. Ngô, A.S. Conrad, P. Trinhammer, H.C. Schmidt, M.-H.S. Sinding, T.M. Williams, and S. Ditlevsen. 2021. Behavioral response study on seismic airgun and vessel exposures in narwhals. **Front. Mar. Sci.** 8:658173.

Heiler, J., S.H. Elwen, H.J. Kriesell, and T. Gridley. 2016. Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. **Animal Behav.** 117:167-177.

Hermannsen, L., J. Tougaard, K. Beedholm, J. Nabe-Nielsen, and P.T. Madsen. 2014. High frequency components of ship noise in shallow water with a discussion of implications for harbor porpoises (*Phocoena phocoena*). **J. Acoust. Soc. Am.** 136(4):1640-1653.

Hermannsen, L., K. Beedholm, J. Tougaard, and P.T. Madsen. 2015. Characteristics and propagation of airgun pulses in shallow water with implications for effects on small marine mammals. **PLoS ONE** 10(7):e0133436.

Heyning, J.E. 1989. Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. p. 289-308 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.

Heyning, J.E. and M.E. Dahlheim. 1988. *Orcinus orca*. **Mammal. Spec.** 304:1-9.

Heyward, A., J. Colquhoun, E. Cripps, D. McCorry, M. Stowar, B. Radford, K. Miller, I. Miller, and C. Battershill. 2018. No evidence of damage to the soft tissue or skeletal integrity of mesophotic corals exposed to a 3D marine seismic survey. **Mar. Poll. Bull.** 129(1):8-13.

Hoelzel, A.R., C.W. Potter, and P.B. Best. 1998. Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin. **Proc. R. Soc Lond. B** 265:1177-1183.

Holt, M.M., D.P. Noren, R.C. Dunkin, and T.M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. **J. Exp. Biol.** 218(11):1647-1654. doi:10.1242/jeb.122424.

Horwood, J. 1987. The sei whale: population biology, ecology, and management. Croom Helm, Beckenham, Kent, UK. 375 p.

Horwood, J. 2018. Sei whale *Balaenoptera borealis*. p. 845-848 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Houghton, J., M.M. Holt, D.A. Giles, M.B. Hanson, C.K. Emmons, J.T. Hogan, T.A. Branch, and G.R. VanBlaricom. 2015. The relationship between vessel traffic and noise levels received by killer whales (*Orcinus orca*). **PLoS ONE** 10(12): e0140119.

Houser, D.S. 2021. When is temporary threshold shift injurious to marine mammals? **J. Mar. Sci. Eng.** 9(7):757.

Houser, D.S., C.D. Champagne, D.E. Crocker. N.M. Kellar, J. Cockrem, T. Romano, R.K. Booth, and S.K. Wasser. 2016. Natural variation in stress hormones, comparisons across matrices, and impacts resulting from induced stress in the bottlenose dolphin. p. 467-471 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Houser, D.S., W. Yost, R. Burkhard, J.J. Finneran, C. Reichmuth, and J. Mulsow. 2017. A review of the history, development and application of auditory weighting functions in humans and marine mammals. **J. Acoust. Soc. Am.** 141(3):1371-1413.

Hoyt, E. and M. Iñíguez. 2008. The state of whale watching in Latin America. Whale and Dolphin Conservation Society, IFAW, Global Ocean, Chippenham, UK.

Huber, H.R. 1991. Changes in the distribution of California sea lions north of the breeding rookeries during the 1982–83 El Niño. p. 129-137 *In*: F. Trillmich and K.A. Ono (eds.), Pinnipeds and El Niño/responses to environmental stress. Springer-Verlag, Berlin. 293 p.

Hückstädt, L.A., L.K. Schwarz, A.S. Friedlaender, B.R. Mate, A.N. Zerbini, A. Kennedy, J. Robbins, N.J. Gales, and D.P. Costa. 2020. A dynamic approach to estimate the probability of exposure of marine predators to oil exploration seismic surveys over continental shelf waters. **Endang. Species Res.** 42:185-199.

Isojunno, S., C. Curé, P.H. Kvadsheim, F.P.A. Lam, P.L. Tyack, P.J. Wensveen, and P.J.O.M. Miller, P.J.O.M. 2016. Sperm whales reduce foraging effort during exposure to 1–2 kHz sonar and killer whale sounds. **Ecol. Appl.** 26(1):77-93.

IUCN (The World Conservation Union). 2024. The IUCN Red List of Threatened Species. Version 2024-2. Accessed October 2024 at http://www.iucnredlist.org/.

IWC (International Whaling Commission). 2007. Report of the standing working group on environmental concerns. Annex K to Report of the Scientific Committee. **J. Cetac. Res. Manage.** 9(Suppl.):227-260.

IWC. 2024a. Whale population estimates. Accessed in October 2024 at https://iwc.int/about-whales/estimate

IWC. 2024b. Mexico. Accessed in October 2024 at https://wwhandbook.iwc.int/en/country-profiles/mexico

Jackson, A., T. Gerrodette, S. Chivers, M. Lynn, P. Olson, and S. Rankin. 2004. Marine mammal data collected during a survey in the Eastern Tropical Pacific Ocean aboard the NOAA ships *Mcarthur II* and *David StarrJordan*, July 29–December 10, 2003. NOAA Tech. Memo. TM-NMFS-SWFSC-366. National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA. 98 p.

Jackson, J.A., D.J. Steel, P. Beerli, B.C. Congdon, C. Olavarría, M.S. Leslie, C. Pomilla, H. Rosenbaum, and C.S. Baker. 2014. Global diversity and oceanic divergence of humpback whales (*Megaptera novaeangliae*). **Proc. R. Soc. B** 281:20133222.

Jaquet, N. and D. Gendron. 2002. Distribution and relative abundance of sperm whales in relation to key environmental features, squid landings and the distribution of other cetacean species in the Gulf of California, Mexico. **Mar. Biol.** 141(3):591-601.

Jaquet, N. and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. **Mar. Ecol. Prog. Ser.** 135(1-3):1-9.

Jefferson, T.A. and N.B. Barros. 1997. *Peponocephala electra*. **Mammal. Species** 553:1-6.

Jefferson, T.A., C.R. Weir, R.C. Anderson, L.T. Ballance, R.D. Kenney, and J.J. Kiszka. 2014. Global distribution of Risso's dolphin *Grampus griseus*: a review and critical evaluation. **Mamm. Rev.** 44(1):56-68.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2015. Marine mammals of the world: a comprehensive guide to their identification, 2nd edit. Academic Press, London, U.K. 608 p.

Jefferson, T.A., F.I. Archer, and K.M. Robertson. 2024. The long-beaked common dolphin of the eastern Pacific Ocean: Taxonomic status and redescription of *Delphinus bairdii*. **Mar. Mamm. Sci.**:e13133.

Jensen, F.H., L. Bejder, M. Wahlberg, N. Aguilar Soto, M. Johnson, and P.T. Madsen. 2009. Vessel noise effects on delphinid communication. **Mar. Ecol. Prog. Ser.** 395:161-175.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Würsig, C.R. Martin, and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):1-19.

Jones, E.L., G.D. Hastie, S. Smout, J. Onoufriou, N.D. Merchant, K.L. Brookes, and D. Thompson. 2017. Seals and shipping: quantifying population risk and individual exposure to vessel noise. **J. Appl. Ecol.** 54(6):1930-1940.

Kastak, D. and C. Reichmuth. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). **J. Acoust. Soc. Am.** 122(5):2916-2924.

Kastak, D., R.L. Schusterman, B.L. Southall, and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinnipeds. **J. Acoust. Soc. Am.** 106(2):1142-1148.

Kastak, D., B.L. Southall, R.J. Schusterman, and C. Reichmuth. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. **J. Acoust. Soc. Am.** 118(5):3154-3163.

Kastak, D., J. Mulsow, A. Ghoul, and C. Reichmuth. 2008. Noise-induced permanent threshold shift in a harbor seal. **J. Acoust. Soc. Am.** 123(5):2986.

Kastelein, R., R. Gransier, L. Hoek, and J. Olthuis. 2012a. Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4 kHz. **J. Acoust. Soc. Am.** 132(5):3525-3537.

Kastelein, R.A., R. Gransier, L. Hoek, A. Macleod, and J.M. Terhune. 2012b. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. **J. Acoust. Soc. Am.** 132(4):2745-2761.

Kastelein, R.A., R. Gransier, L. Hoek, and C.A.F. de Jong. 2012c. The hearing threshold of a harbor porpoise (*Phocoena phocoena*) for impulsive sounds (L). **J. Acoust. Soc. Am.** 132(2):607-610.

Kastelein, R.A., N. Steen, R. Gransier, and C.A.F. de Jong. 2013a. Brief behavioral response threshold level of a harbor porpoise (*Phocoena phocoena*) to an impulsive sound. **Aquat. Mamm.** 39(4):315-323.

Kastelein, R.A., R. Gransier, L. Hoek, and M. Rambags. 2013b. Hearing frequency thresholds of a harbour porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5-kHz tone. **J. Acoust. Soc. Am.** 134(3):2286-2292.

Kastelein, R., R. Gransier, and L. Hoek. 2013c. Comparative temporary threshold shifts in a harbour porpoise and harbour seal, and severe shift in a seal. **J. Acoust. Soc. Am.** 134(1):13-16.

Kastelein, R.A., L. Hoek, R. Gransier, M. Rambags, and N. Clayes. 2014. Effect of level, duration, and inter-pulse interval of 1–2 kHz sonar signal exposures on harbor porpoise hearing. **J. Acoust. Soc. Am.** 136:412-422.

Kastelein, R.A., R. Gransier, J. Schop, and L. Hoek. 2015a. Effects of exposure to intermittent and continuous 6-7 kHz sonar sweeps on harbor porpoise (*Phocoena phocoena*) hearing. **J. Acoust. Soc. Am.** 137(4):1623-1633.

Kastelein, R.A., R. Gransier, M.A.T. Marijt, and L. Hoek. 2015b. Hearing frequency thresholds of harbor porpoises (*Phocoena phocoena*) temporarily affected by played back offshore pile driving sounds. **J. Acoust. Soc. Am.** 137(2):556-564.

Kastelein, R.A., R. Gransier, and L. Hoek. 2016a. Cumulative effects of exposure to continuous and intermittent sounds on temporary hearing threshold shifts induced in a harbor porpoise (*Phocoena phocoena*). p. 523-528 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Kastelein, R.A., L. Helder-Hoek, J. Covi, and R. Gransier. 2016b. Pile driving playback sounds and temporary threshold shift in harbor porpoises (*Phocoena phocoena*): effect of exposure duration. **J. Acoust. Soc. Am.** 139(5):2842-2851.

Kastelein, R.A., L. Helder-Hoek, S. Van de Voorde, A.M. von Benda-Beckmann, F.P.A. Lam, E. Jansen, C.A.F. de Jong, and M.A. Ainslie. 2017. Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) after exposure to multiple airgun sounds. **J. Acoust. Soc. Am.** 142(4):2430-2442.

Kastelein, R.A., L. Helder-Hoek, and J.M. Terhune. 2018. Hearing thresholds, for underwater sounds, of harbor seals (*Phoca vitulina*) at the water surface. **J. Acoust. Soc. Am.** 143:2554-2563.

Kastelein, R.A., L. Helder-Hoek, and R. Gransier. 2019a. Frequency of greatest temporary hearing threshold shift in harbor seals (*Phoca vitulina*) depends on fatiguing sound level. **J. Acoust. Soc. Am.** 145(3):1353-1362.

Kastelein, R.A., L. Helder-Hoek, R. van Kester, R. Huisman, and R. Gransier. 2019b. Temporary threshold shift in harbor porpoises (*Phocoena phocoena*) due to one-sixth octave noise band at 16 kHz. **Aquatic Mamm.** 45(3):280-292.

Kastelein, R.A., L. Helder-Hoek, R. van Kester, R. Huisman, and R. Gransier. 2019c. Temporary threshold shift in harbor porpoises (*Phocoena phocoena*) due to one-sixth octave noise band at 16 kHz. **Aquatic Mamm.** 45(3):280-292.

Kastelein, R.A., L. Helder-Hoek, S. Cornelisse, L.A.E. Huijser, and Gransier. 2019d. Temporary threshold shift in harbor porpoises (*Phocoena phocoena*) due to one-sixth octave noise band at 32 kHz. **Aquatic Mamm.** 45(5):549-562.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, L.A.E. Huijser, and J.M. Terhune. 2020a. Temporary hearing threshold shift in harbor seals (*Phoca vitulina*) due to a one-sixth-octave noise band centered at 32 kHz. **J. Acoust. Soc. Am.** 147(3):1885-1896.

Kastelein, R.A., C. Parlog., L. Helder-Hoek, S.A. Cornelisse, L.A.E. Huijser, and J.M. Terhune. 2020b. Temporary hearing threshold shift in harbor seals (*Phoca vitulina*) due to a one-sixth-octave noise band centered at 40 kHz. **J. Acoust. Soc. Am.** 147(3):1966-1976.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, L.N. Defillet, L.A.E. Huijser, and J.M. Terhune. 2020c. Temporary hearing threshold shift in harbor seals (*Phoca vitulina*) due to a one-sixth-octave noise bands centered at 0.5, 1, and 2 kHz. **J. Acoust. Soc. Am.** 148(6):3873-3885.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, L.N. Defillet, L.A.E. Huijser, and J.M. Terhune. 2020d. Temporary hearing threshold shift in harbor porpoises (*Phocoena phocoena*) due to one-sixth-octave noise bands centered at 63 kHz. **Aquatic Mamm.** 46(2):167-182.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, L.A.E. Huijser, and J.M. Terhune. 2020e. Temporary hearing threshold shift at ecologically relevant frequencies in a harbor porpoise (*Phocoena phocoena*) due to exposure to a noise band centered at 88.4 kHz. **Aquatic Mamm.** 46(5):444-453.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, L.N. Defillet, and L.A. Huijser. 2020f. Temporary hearing threshold shift in a second harbor porpoise (*Phocoena phocoena*) after exposure to a one-sixth-octave noise band at 1.5 kHz and 6.5 kHz continuous wave. **Aquatic Mamm.** 46(5):431-443.

Kastelein, R.A., L. Helder-Hoek, S.A. Cornelisse, A.M. von Benda-Beckmann, F.P.A. Lam, C.A.F. de Jong, and D.R. Ketten. 2020g. Lack of reproducibility of temporary hearing threshold shifts in a harbor porpoise after exposure to repeated airgun sounds. **J. Acoust. Soc. Am.** 148:556-565.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, L.A. Huijser, J.M. Terhune, and R. Gransier. 2021a. Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) due to exposure to a continuous one-sixth-octave noise band centered at 0.5 kHz. **Aquatic Mamm.** 47(2):135-145.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, L.A. Huijser, J.M. Terhune, and R. Gransier. 2021b. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to one-sixth-octave noise bands centered at 2 and 4 kHz: effect of duty cycle and testing the equal-energy hypothesis. **Aquatic Mamm.** 47(4):394-418.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, L.A. Huijser, J.M. Terhune, and R. Gransier. 2022a. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to one-sixth-octave noise bands centered at 8 and 16 kHz: effect of duty cycle and testing the equal-energy hypothesis. **Aquatic Mamm.** 48(1):36-58.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, L. Van Acoleyen, L.A. Huijser, and J.M. Terhune. 2022b. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to one-sixth-octave noise bands centered at 0.6 and 1 kHz. **Aquatic Mamm.** 48(3):248-265.

Kastelein, R.A., L. Helder-Hoek, L.N. Defillet, J.M. Terhune, R. Beutelmann, and G.M. Klump. 2023a. Masking release at 4 and 32 kHz in harbor seals associated with sinusoidal amplitude-modulated masking noise. **J. Acoust. Soc. Am.** 154(1):81-94.

Kastelein, R.A., L. Helder-Hoek, L. Van Acoleyen, L.N. Defillet, and J.M. Terhune. 2024. Temporary hearing threshold shift in California sea lions (*Zalophus californianus*) due to a noise band centered at 32 kHz. **Aquatic Mamm.** 50(2):107-121.

Kasuya, T. 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. **Sci. Rep. Whales Res. Inst.** 37:61-83.

Kasuya, T. and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. **Sci. Rep. Whales Res. Inst.** 39:31-75.

Kato, H. and W.F. Perrin. 2018. Bryde's whale *Balaenoptera edeni*. p. 143-145 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Kavanagh, A.S., M. Nykänen, W. Hunt, N. Richardson, and M.J. Jessopp. 2019. Seismic surveys reduce cetacean sightings across a large marine ecosystem. **Sci. Rep.** 9:19164.

Kellar, N.M., M.L. Trego, S.J. Chivers, and F.I. Archer. 2013. Pregnancy patterns of pantropical spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific determined from hormonal analysis of blubber biopsies and correlations with the purse-seine tuna fishery. **Mar. Biol.** 160(12): 3113-3124.

Kenney, R.D. and H.E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. **Continent. Shelf Res.** 7:107-114.

Ketten, D.R. 2012. Marine mammal auditory system noise impacts: evidence and incidence. p. 207-212 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Ketten, D.R., J. O'Malley, P.W.B. Moore, S. Ridgway, and C. Merigo. 2001. Aging, injury, disease, and noise in marine mammal ears. **J. Acoust. Soc. Am.** 110(5, Pt. 2):2721.

King, S.L., R.S. Schick, C. Donovan, C.G. Booth, M. Burgman, L. Thomas, and J. Harwood. 2015. An interim framework for assessing the population consequences of disturbance. **Meth. Ecol. Evol. 6**(1):1150-1158.

Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, P. Olson, and A. Von Saunder. 1999. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* and the UNOLS ship *Endeavor* July 31-December 9, 1998. NOAA Tech. Memo. NMFS, U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-283. 113 p.

Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, and P. Olson. 2000. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28-December 9, 1998. NOAA Tech. Memo. NMFS, U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-293. 89 p.

Kinzey, D., T. Gerrodette, A. Dizon, W. Perryman, P. Olson, and S. Rankin. 2001. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan*, July 28-December 9, 2000. NOAA Tech. Memo. NMFS, U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-303. 100 p.

Klinck, H., S.L. Nieukirk, D.K. Mellinger, K. Klinck, H. Matsumoto, and R.P. Dziak. 2012. Seasonal presence of cetaceans and ambient noise levels in polar waters of the North Atlantic. **J. Acoust. Soc. Am.** 132(3):EL176-EL181.

Kok, A.C.M., J.P. Engelberts, R.A. Kastelein, L. Helder-Hoek, S. Van de Voorde, F. Visser, and H. Slabbekoorn. 2017. Spatial avoidance to experimental increase of intermittent and continuous sound in two captive harbour porpoises. **Environ. Poll.** 233:1024-1036.

Krieger, K.J. and B.L. Wing. 1984. Hydroacoustic surveys and identification of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick Sound, southeastern Alaska, summer 1983. NOAA Tech. Memo. NMFS F/NWC-66. U.S. Natl. Mar. Fish. Serv., Auke Bay, AK. 60 p. NTIS PB85-183887.

Krieger, K.J. and B.L. Wing. 1986. Hydroacoustic monitoring of prey to determine humpback whale movements. NOAA Tech. Memo. NMFS F/NWC-98. U.S. Natl. Mar. Fish. Serv., Auke Bay, AK. 63 p. NTIS PB86-204054.

Kruse, S., D.K. Caldwell, and M.C. Caldwell. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). p. 183-212 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second book of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Kujawa, S.G. and M.C. Liberman. 2009. Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. **J. Neurosci.** 29(45):14077-14085.

Kunc, H.P., K.E. McLaughlin, and R. Schmidt. 2016. Aquatic noise pollution: implications for individuals, populations, and ecosystems. **Proc. R. Soc. B** 283:20160839.

Kyhn, L.A., D.M. Wisniewska, K. Beedholm, J. Tougaard, M. Simon, A. Mosbech, and P.T. Madsen. 2019. Basin-wide contributions to the underwater soundscape by multiple seismic surveys with implications for marine mammals in Baffin Bay, Greenland. **Mar. Poll. Bull.** 138:474-490.

Lalas, C. and H. McConnell. 2015. Effects of seismic surveys on New Zealand fur seals during daylight hours: do fur seals respond to obstacles rather than airgun noise? **Mar. Mamm. Sci.** 32(2):643-663.

Landrø, M. and J. Langhammer. 2020. Comparing the broadband acoustic frequency response of single, clustered, and arrays of marine air guns. **Geophysics** 85(3):P27-P36.

Laute, A., T.J. Grove, M.H. Rasmussen, A. Smith, O. Loisa, and M.E.H. Fournet. 2022. Impact of whale-watching vessels on humpback whale calling behavior on an Icelandic foraging ground during the Covid-19 pandemic. **Mar. Ecol. Prog. Ser.** 701:159-173.

Laws, R. 2012. Cetacean hearing-damage zones around a seismic source. p. 473-476 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Lazcano-Pacheco, C., M.A. Onofre-Díaz, R. Meza-Yañez, M. Llamas-González, L.M. Bautista-Moreno, A. Olivos-Ortiz, and C.D. Ortega-Ortiz. 2022. Cetacean Mortality Related to Ship Traffic in the Mexican Central Pacific. **Aquatic Mammals**:48(6):737-745.

Le Prell, C.G. 2012. Noise-induced hearing loss: from animal models to human trials. p. 191-195 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Leatherwood, S., R.R. Reeves, W.F. Perrin, and W.E. Evans. 1988. Whales, dolphins and porpoises of the Eastern North Pacific and Adjacent Arctic Waters. Dover Publications, New York, NY. 245 p.

Lesage, V., A. Omrane, T. Doniol-Valccroze, and A. Mosnier. 2017. Increased proximity of vessels reduces feeding opportunities of blue whales in St. Lawrence Estuary, Canada. **Endang. Species Res.** 32:351–361.

Leslie, M.S. and P.A. Morin. 2016. Using genome-wide SNPs to detect structure in high-diversity and low-divergence populations of severely impacted eastern tropical Pacific spinner (*Stenella longirostris*) and Pantropical spotted dolphins (*S. attenuata*). **Front. Mar. Sci.** 3:253. .

Leslie, M.S., F.I. Archer, and P.A. Morin. 2019. Mitogenomic differentiation in spinner (*Stenella longirostris*) and pantropical spotted dolphins (*S. attenuata*) from the eastern tropical Pacific Ocean. **Mar. Mamm. Sci.** 35(2):522-551.

LGL Limited. 2022. Final Environmental Analysis of Marine Geophysical Surveys by R/V *Marcus G. Langseth* off Western Mexico, Eastern Tropical Pacific Ocean. LGL Report FA0221-01A prepared for Lamont-Doherty Earth Observatory, Palisades, NY and National Science Foundation, Arlington, VA.

Liberman, M.C., M.J. Epstein, S.S. Cleveland, H. Wang, and S.F. Maison. 2016. Toward a differential diagnosis of hidden hearing loss in humans. **PLoS ONE** 11(9):e0162726.

Lowry, M.S., P. Boveng, R.J. DeLong, C.W. Oliver, B.S. Stewart, H. DeAnda, and J. Barlow. 1992. Status of the California sea lion (*Zalophus californianus californianus*) population in 1992. Admin. Rep. LJ-92-32. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA 92038. 34 p.

Lucke, K., U. Siebert, P.A. Lepper, and M.-A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. **J. Acoust. Soc. Am.** 125(6):4060-4070.

Lucke, K., S.B. Martin, and R. Racca. 2020. Evaluating the predictive strength of underwater noise exposure criteria for marine mammals. **J. Acoust. Soc. Am.** 147:3985.

Luís, A.R., M.N. Couchinho, and M.E. Dos Santos. 2014. Changes in the acoustic behavior of resident bottlenose dolphins near operating vessels. **Mar. Mamm. Sci.** 30(4):1417-1426.

Lurton, X. 2016. Modelling of the sound field radiated by multibeam echosounders for acoustical impact assessment. **Appl. Acoust.** 101:201-216.

Lusseau, D. and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance experience from whalewatching impact assessment. **Int. J. Comp. Psych.** 20(2-3):228-236.

Lyamin, O.I., S.M. Korneva, V.V. Rozhnov, and L.M. Mukhametov. 2016. Cardiorespiratory responses to acoustic noise in belugas. p. 665-672 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

MacGillivray, A.O., R. Racca, and Z. Li. 2014. Marine mammal audibility of selected shallow-water survey sources. **J. Acoust. Soc. Am.** 135(1):EL35-EL40.

MacLeod, C.D. and G. Mitchell. 2006. Key areas for beaked whales worldwide. **J. Cetacean Res. Manage.** 7(3): 309-322.

MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D., Mullin, D.L. Palka, and G.T. Waring. 2005. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). **J. Cetacean Res. Manage.** *7*(3):271-286.

Malme, C.I. and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. p. 253-280 *In*: G.D. Greene, F.R. Engelhardt, and R.J. Paterson (eds.), Proc. Worksh. Effects Explos. Mar. Envir., Jan. 1985, Halifax, N.S. Tech. Rep. 5. Can. Oil & Gas Lands Admin., Environ. Prot. Br., Ottawa, ON. 398 p.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. NTIS PB86-218377.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Rep. 5851; OCS Study MMS 85-0019. Rep. from BBN Labs Inc., Cambridge, MA, for MMS, Anchorage, AK. NTIS PB86-218385.

Maniscalco J.M., K. Wynne, K.W. Pitcher, M.B. Hanson, S.R. Melin, and S. Atkinson. 2004. The occurrence of California sea lions in Alaska. **Aquatic Mamm.** 30:427-433.

Maravilla-Chavez, M.O. and M.S. Lowry. 1999. Incipient breeding colony of Guadalupe fur seals at isla Benito del este, Baja California, Mexico. **Mar. Mamm. Sci.** 15(1):239-241.

Martien, K.K., B.L. Taylor, F.I. Archer, K. Audley, J. Calambokidis, T. Cheeseman, J. De Weerdt, A. Frisch-Jordán, P. Martínez-Loustalot, C.D. Ortega-Ortiz, E.M. Patterson, N. Ransome, P. Ruvelas, J. Urbán Ramírez, and F. Villegas-Zurita. 2021. Evaluation of Mexico Distinct Population Segment of Humpback Whales as units under the Marine Mammal Protection Act. U.S. Deparment of Commerce, NOAA Tech Memo NMFS-SWFSC-658.

Martin, M.J., W.D. Halliday, L. Storrie, J.J. Citta, J. Dawson, N.E. Hussey, F. Juanes, L.L. Loseto, S.A. MacPhee, L. Moore, and A. Nicoll. 2023a. Exposure and behavioral responses of tagged beluga whales (*Delphinapterus leucas*) to ships in the Pacific Arctic. **Mar. Mamm. Sci.** 39(2):387-421.

Martin, M.J., W.D. Halliday, J.J. Citta, L. Quakenbush, L. Harwood, E.V. Lea, F. Juanes, J. Dawson, A. Nicoll, and S.J. Insley. 2023b. Exposure and behavioural responses of tagged bowhead whales (*Balaena mysticetus*) to vessels in the Pacific Arctic. **Arctic Sci.** 9:600-615.

Martin, S.B., K. Lucke, and D.R. Barclay. 2020. Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals. **J. Acoust. Soc. Am.** 147(4):2159-2176.

Martínez-Loustalot, P., K. Audley, T. Cheeseman, J. De Weerdt, A. Frisch-Jordán, O. Guzón, M. Olio, C.D. Ortega-Ortiz, N. Ransome, F. Villegas-Zurita, and R.J. Urbán. 2023. Towards the definition of the humpback whale population units along the Mexican and Central American coasts in the Pacific Ocean. **Mar. Mamm. Sci.** 39(2):422-437.

Martins, D.T.L., M.R. Rossi-Santos, and F.J. De Lima Silva. 2016. Effects of anthropogenic noise on the acoustic behaviour of *Sotalia guianensis* (Van Bénéden, 1864) in Pipa, North-eastern Brazil. **J. Mar. Biol. Assoc. U.K.** 2016:1-8.

Mate, B.R., B.A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during the feeding season off southern California and their southern fall migration. **Mar. Mamm. Sci.** 15(4):1246-1257.

Matos, F. 2015. Distribution of cetaceans in Vestfjorden, Norway, and possible impacts of seismic surveys. M.Sc. Thesis, University of Nordland, Norway. 45 p.

Matthews, L. 2017. Harbor seal (*Phoca vitulina*) reproductive advertisement behavior and the effects of vessel noise. Ph.D. Thesis, Syracuse University. 139 p.

Matthews, L.P. and S.E. Parks. 2021. An overview of North Atlantic right whale acoustic behavior, hearing capabilities, and responses to sound. **Mar. Poll. Bull.** 173:113043.

Mauro, M., I. Pérez-Arjona, E.J. Belda Perez, M. Ceraulo, M. Bou-Cabo, T. Benson, V. Espinosa, F. Beltrame, S. Mazzola, M. Vazzana, and G. Buscano. 2020. The effect of low frequency noise on the behaviour of juvenile *Sparus aurata*. **J. Acoust. Soc. Am.** 147(6):3795-3807.

May-Collado, L., T. Gerrodette, J. Calambokidis, K. Rasmussen, and I. Sereg. 2005. Patterns of cetacean sighting distribution in the Pacific Exclusive Economic Zone of Costa Rica based on data collected from 1979-2001. **Rev Biol. Trop.** 53:249-263.

McAlpine, D.F. 2018. Pygmy and dwarf sperm whales. p. 786-788 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

McCarthy, E., D. Moretti, L. Thomas, N. DiMarzio, R. Morrissey, S. Jarvis, J. Ward, A. Izzi, and A. Dilley. 2011. Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (*Mesoplodon densirostris*) during multiship exercises with mid-frequency sonar. **Mar. Mamm. Sci.** 27(3):E206-E226.

McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. **APPEA (Austral. Petrol. Product. Explor. Assoc.) J.** 38:692-707.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Rep. from Centre for Marine Science and Technology, Curtin Univ., Perth, Western Australia, for Australian Petrol. Produc. & Explor. Assoc., Sydney, NSW. 188 p.

McCauley, R.D., M.G. Meekan, and M.J. Parsons. 2021. Acoustic pressure, particle motion, and induced ground motion signals from a commercial seismic survey array and potential implications for environmental monitoring. **J. Mar. Sci. Eng.** 9(6):571.

McDonald, T.L., W.J. Richardson, K.H. Kim, and S.B. Blackwell. 2010. Distribution of calling bowhead whales exposed to underwater sounds from Northstar and distant seismic surveys, 2009. p. 6-1 to 6-38 *In*: W.J. Richardson (ed.), Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea: Comprehensive report for 2005–2009. LGL Rep. P1133-6. Rep. by LGL Alaska Res. Assoc. Inc., Anchorage, AK, Greeneridge Sciences Inc., Santa Barbara, CA, WEST Inc., Cheyenne, WY, and Applied Sociocult. Res., Anchorage, AK, for BP Explor. (Alaska) Inc., Anchorage, AK. 265 p.

McDonald, T.L., W.J. Richardson, K.H. Kim, S.B. Blackwell, and B. Streever. 2011. Distribution of calling bowhead whales exposed to multiple anthropogenic sound sources and comments on analytical methods. p. 199 *In*: Abstr. 19th Bienn. Conf. Biol. Mar. Mamm., 27 Nov.–2 Dec. 2011, Tampa, FL. 344 p.

McGeady, R., B.J. McMahon, and S. Berrow. 2016. The effects of surveying and environmental variables on deep diving odontocete stranding rates along Ireland's coast. **Proceedings of Meetings on Acoustics 4ENAL** 27(1):040006.

McGrew, K.A., S.E. Crowell, J.L. Fiely, A.M. Berlin, G.H. Olsen, J. James, H. Hopkins, and C.K. Williams. 2022. Underwater hearing in sea ducks with applications for reducing gillnet bycatch through acoustic deterrence. **J. Exp. Biol.** 225:jeb243953.

McHuron, E.A., L. Aerts, G. Gailey, O. Sychenko, D.P. Costa, M. Mangel, and L.K. Schwartz. 2021. Predicting the population consequences of acoustic disturbance, with application to an endangered gray whale population. **Ecol. Appl.** 31(8):p.e02440.

McKenna, M.F., J. Calambokidis, E.M. Oleson, D.W. Laist, and J.A. Goldbogen. 2015. Simultaneous tracking of blue whales and large ships demonstrate limited behavioral responses for avoiding collision. **Endang. Species. Res.** 27:219-232.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. p. 349-430 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.

Meier, S.K., S.B. Yazvenko, S.A. Blokhin, P. Wainwright, M.K. Maminov, Y.M. Yakovlev, and M.W. Newcomer. 2007. Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. **Environ. Monit. Assess.** 134(1-3):107-136.

Melcón, M.L., A.J. Cummins, S.M. Kerosky, L.K. Roche, S.M. Wiggins, and J.A. Hildebrand. 2012. Blue whales respond to anthropogenic noise. **PLoS ONE** 7(2):e32681.

Meraz, J. and V.M. Sánchez-Díaz. 2008. Los mamíferos marinos en la costa central de Oaxaca. **Rev. Mex. Biodiv.** 79(1):143-51.

Merkens, K., Y. Barkley, H. Hill, and E. Oleson. 2016. Dwarf sperm whale (*Kogia sima*) echolocation clicks from Guam (western North Pacific Ocean). **J. Acoust. Soc. Am.** 140(4):3415-3415.

Mikkelsen, L., M. Johnson, D.M. Wisniewska, A. van Neer, U. Siebert, P.T. Madsen, and J. Teilmann. 2019. Long-term sound and movement recording tags to study natural behavior and reaction to ship noise of seals. **Ecol. Evol.** 9(5):2588-2601.

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton, and W.J. Richardson. 1999. Whales. p. 5-1 to 5-109 *In*: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001–2002. p. 511-542 *In*: S.L. Armsworthy, P.J. Cranford, and K. Lee (eds.), Offshore oil and gas environmental effects monitoring: approaches and technologies. Battelle Press, Columbus, OH. 631 p.

Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, M. Quero, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. **Deep-Sea Res. I** 56(7):1168-1181.

Miller, P.J., S. Isojunno, E. Siegal, F.P.A. Lam, P.H. Kvadsheim, and C. Curé. 2022. Behavioral responses to predatory sounds predict sensitivity of cetaceans to anthropogenic noise within a soundscape of fear. **Proc. Nat. Acad. Sci.** 119(13):e2114932119.

Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). p. 1-21 *In:* S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 5. The first book of dolphins. Academic Press, San Diego, CA. 416 p.

Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J. Waite, and W.L. Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. **Mammal. Rev.** 39(3):193-227.

Monaco, C., J.M. Ibáñez, F. Carrión, and L.M. Tringali. 2016. Cetacean behavioural responses to noise exposure generated by seismic surveys: how to mitigate better? **Ann. Geophys.** 59(4):S0436. doi:10.4401/ag-7089.

Monnahan, C.C., T.A. Branch, K.M. Stafford, Y.V. Ivashchenko, and E.M. Oleson. 2014. Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. **PLoS ONE** 9(6). doi:10.1371/journal.pone.0098974.

Moore, S.E., K.M. Stafford, M.E. Dahlheim, C.G. Fox, H.W. Braham, J.J. Polovina, and D.E. Bain. 1998. Seasonal variation in reception of fin whale calls at five geographic areas in the North Pacific. **Mar. Mamm. Sci.** 14(3):617-627.

Moore, S.E., K.M. Stafford, D.K. Mellinger, and C.G. Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. **BioScience** 56(1):49-55.

Morell, M., A. Brownlow, B. McGovern, S.A. Raverty, R.E. Shadwick, and M. André. 2017. Implementation of a Morell, M., A. Brownlow, B. McGovern, S.A. Raverty, R.E. Shadwick, and M. André.

2017. Implementation of a method to visualize noise-induced hearing loss in mass stranded cetaceans. **Sci. Rep.** 7:41848.

Morell, M., A. . Vogl, L.L. IJsseldijk, M. Piscitelli-Doshkov, L. Tong, S. Ostertag, M. Ferreira, N. Fraija-Fernandez, K.M. Colegrove, J.-L. Puel, S.A. Raverty, and R.E. Shadwick. 2020. Echolocating whales and bats express the motor protein prestin in the inner ear: A potential marker for hearing loss. **Front. Vet. Sci.** 17:7:429.

Morell, M., L.L. IJsseldijk, A.J. Berends, A. Gröne, U. Siebert, S.A. Raverty, R.E. Shadwick, M.J.L. Kik. 2021. Evidence of hearing loss and unrelated toxoplasmosis in a free-ranging harbour porpoise (*Phocoena phocoena*). Animals 11:3058.

Mortensen, L.O., M.E. Chudzinska, H. Slabbekoorn, and F. Thomsen. 2021. Agent-based models to investigate sound impact on marine animals: bridging the gap between effects on individual behaviour and population level consequences. **Oikos** 130(7):1074-1086

Moulton, V.D. and M. Holst. 2010. Effects of seismic survey sound on cetaceans in the Northwest Atlantic. Environ. Stud. Res. Funds Rep. No. 182. St. John's, Nfld. 28 p.

Muir, J.E., L. Ainsworth, R. Joy, R. Racca, Y. Bychkov, G. Gailey, V. Vladimirov, S. Starodymov, and K. Bröker. 2015. Distance from shore as an indicator of disturbance of gray whales during a seismic survey off Sakhalin Island, Russia. **Endang. Species. Res.** 29:161-178.

Muir, J.E., L. Ainsworth, R. Racca, Y. Bychkov, G. Gailey, V. Vladimirov, S. Starodymov, and K. Bröker. 2016. Gray whale densities during a seismic survey off Sakhalin Island, Russia. **Endang. Species Res.** 29(2):211-227.

Mulsow, J., C.E. Schlundt, L. Brandt, and J.J. Finneran. 2015. Equal latency contours for bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*). **J. Acoust. Soc. Am.** 138(5): 2678-2691.

Mulsow, J., C.E. Schlundt, M.G. Strahan, and J. Finneran. 2023. Bottlenose dolphin temporary threshold shift following exposure to 10-ms impulses centered at 8 kHz. **J. Acoust. Soc. Am.** 154(2):1287-1298.

Muto, M.M, V.T. Helker, B.J. Delean, N.C. Young, J.C. Freed, R.P. Angliss, N.A. Friday, P.L. Boveng, J.M. Breiwick, B.M Brost, M.F. Cameron, P.J. Clapham, J.C. Crance, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, K.L. Sweeney, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2021. Alaska marine mammal stock assessments, 2020. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-AFSC-421. 398 p.

Muzquiz-Villalobos, M. and S. Pompa-Mansilla. 2018. Marine mammals of Mexico: Richness patterns, protected areas, and conservation trends. **Estuar. Coast. Shelf Sci.** 208:153-160.

Nachtigall, P.E. and A.Y. Supin. 2013. A false killer whale reduces its hearing sensitivity when a loud sound is preceded by a warning. **J. Exp. Biol.** 216:3062-3070.

Nachtigall, P.E. and A.Y. Supin. 2014. Conditioned hearing sensitivity reduction in the bottlenose dolphin (*Tursiops truncatus*). **J. Exp. Biol.** 217(15): 2806-2813.

Nachtigall, P.E. and A.Y. Supin. 2015. Conditioned frequency-dependent hearing sensitivity reduction in the bottlenose dolphin (*Tursiops truncatus*). **J. Exp. Biol.** 218(7): 999-1005.

Nachtigall, P.E. and A.Y. Supin. 2016. Hearing sensation changes when a warning predict a loud sound in the false killer whale (*Pseurorca crassidens*). p. 743-746 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Nachtigall, P.E., A.Y. Supin, A.F. Pacini, and R.A. Kastelein. 2018. Four odontocete species change hearing levels when warned of impending loud sound. **Integr. Zool.** 13(2):160-165.

National Academies of Sciences, Engineering, and Medicine. 2017. Approaches to understanding the cumulative effects of stressors on marine mammals. The National Academies Press. Washington, DC. 134 p.

New, L.F., J. Harwood, L. Thomas, C. Donovan, J.S. Clark, G. Hastie, P.M. Thompson, B. Cheney, L. Scott-Hayward, and D. Lusseau. 2013a. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. **Funct. Ecol.** 27(2):314-322.

New, L.F., D. Moretti, S.K. Hooker, D.P. Costa, and S.E. Simmons. 2013b. Using energetic models to investigate the survival and reproduction of beaked whales (family Ziphiidae). **PLoS ONE** 8(7):e68725.

Nieukirk, S.L., D.K. Mellinger, S.E. Moore, K. Klinck, R.P. Dziak, and J. Goslin. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. **J. Acoust. Soc. Am.** 131(2):1102-1112.

NMFS (National Marine Fisheries Service). 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). Prepared by R.R. Reeves, P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber for the Nat. Mar. Fish. Serv., Silver Spring, MD. 42 p.

NMFS. 2001. Small takes of marine mammals incidental to specified activities: oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an incidental harassment authorization. **Fed. Reg.** 66(26, 7 Feb.):9291-9298.

NMFS. 2013. Effects of oil and gas activities in the Arctic Ocean: supplemental draft environmental impact statement. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. Accessed in October 2021 at https://www.fisheries.noaa.gov/national/marine-mammal-protection/environmental-impact-statement-eis-effects-oil-and-gas-activities.

NMFS. 2015. Taking and importing marine mammals; taking marine mammals incidental to Southwest Fisheries Science Center Fisheries Research. Final Rule. **Fed. Reg.** 80(189, 30 Sept.):58982-59013.

NMFS. 2016a. Endangered and threatened species; identification of 14 distinct population segments of the humpback whale (*Megaptera novaeangliae*) and revision of species-wide listing. Final Rule. **Fed. Reg.** 81(174, 8 Sept.):62260-62320.

NMFS. 2016b. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: underwater acoustic thresholds for onset of permanent and temporary threshold shifts. U.S. Depart. Commerce, National Oceanic and Atmospheric Administration. 178 p.

NMFS. 2018. 2018 revision to: technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Office of Protected Resources Nat. Mar. Fish. Serv., Silver Spring, MD. 167 p.

NMFS. 2019a. Takes of marine mammals incidental to specified activities; taking marine mammals incidental to a marine geophysical survey in the Gulf of Alaska. **Fed. Reg.** 84(113, 12 June):27246-27270.

NMFS. 2019b. Takes of marine mammals incidental to specified activities; taking marine mammals incidental to a marine geophysical survey in the Northeast Pacific Ocean. **Fed. Reg.** 84(140, 22 July):35073-35099.

NMFS. 2024. 2024 Update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 3.0). Underwater thresholds for onset of permanent and temporary threshold shifts. NOAA Tech. Memo. NMFS-OPR-71. Available at https://www.fisheries.noaa.gov/s3/2024-10/Tech-Memo-Guidance-3.0-OCT2024-508-OPR1.pdf.

NOAA. 2024a. Species Directory. Accessed October 2024 at https://www.fisheries.noaa.gov/species-directory/threatneed-endangered.

NOAA. 2024b. 2015–2021 Guadalupe Fur Seal Unusual Mortality Event in California, Oregon and Washington. Accessed October 2024 at https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2021-guadalupe-fur-seal-and-2015-northern-fur-seal-unusual

NOAA. 2024c. Active and closed unusual mortality events. Accessed in October 2024 at https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

Noad, M. and R. Dunlop. 2023. Humpback whales increase the length of their songs during nearby airgun operations. **J. Acoust. Soc. Am.** 154(4 Supplement):A88.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. **Mamm. Rev.** 37(2):81-115.

Nowacek, D.P., A.I. Vedenev, B.L. Southall, and R. Racca. 2012. Development and implementation of criteria for exposure of western gray whales to oil and gas industry noise. p. 523-528 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Nowacek, D.P., K. Bröker, G. Donovan, G. Gailey, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and B.L. Southall. 2013a. Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. **Aquatic Mamm.** 39(4):356-377.

Nowacek, D.P., K. Bröker, G. Donovan, G. Gailey, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and B.L. Southall. 2013b. Environmental impacts of marine seismic surveys with an emphasis on marine mammals. **Aquatic Mamm.** 39(4):356-377.

Nowacek, D.P., C.W. Clark, P. Mann, P.J.O. Miller, H.C. Rosenbaum, J.S. Golden, M. Jasny, J. Kraska, and B.L. Southall. 2015. Marine seismic surveys and ocean noise: time for coordinated and prudent planning. **Front. Ecol. Environ.** 13(7):378-386.

Nowacek, D.P., F. Christiansen, L. Bejder, J.A. Goldbogen, and A.S. Friedlaender. 2016. Studying cetacean behaviour: new technological approaches and conservation applications. **Animal Behav.** 120:235-244.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise/Determining when noise causes biologically significant effects. U.S. Nat. Res. Counc., Ocean Studies Board, Committee on characterizing biologically significant marine mammal behavior (Wartzok, D.W., J. Altmann, W. Au, K. Ralls, A. Starfield, and P.L. Tyack). Nat. Acad. Press, Washington, DC. 126 p.

NSF (National Science Foundation). 2012. Record of Decision for marine seismic research funded by the National Science Foundation. June 2012. 41 p.

NSF and USGS (National Science Foundation and U.S. Geological Survey). 2011. Final programmatic environmental impact statement/Overseas environmental impact statement for marine seismic research funded by the National Science Foundation or conducted by the U.S. Geological Survey.

O'Brien, J.M., S. Beck, S.D. Berrow, M. André, M. van der Schaar, I. O'Connor, and E.P. McKeown. 2016. The use of deep water berths and the effect of noise on bottlenose dolphins in the Shannon Estuary cSAC. p. 775-783 *In*: The effects of noise on aquatic life II, Springer, New York, NY. 1292 p.

Oakley, J.A., A.T. Williams, and T. Thomas. 2017. Reactions of harbour porpoise (*Phocoena phocoena*) to vessel traffic in the coastal waters of South Wales, UK. **Ocean Coastal Manage.** 138:158-169.

OBIS (Ocean Biogeographic Information System). 2021. Data from the Ocean Biogeographic Information System. Intergovernmental Oceanographic Commission of UNESCO. Accessed July 2021 at http://www.iobis.org.

Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). p. 213-243 *In:* S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals. Vol. 6. The second Book of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Oedekoven, C.S., L. McMillan, S. Fatima, D. Harris-Birtill, C. Faustino, L. Marshall, S.T. Buckland, and C.E. Lennert-Cody. 2021. Trial survey for eastern tropical Pacific dolphins: project report. Inter-American Tropical Tuna Commission Special Report 24. La Jolla, California.

Ohsumi, S. and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. **Rep. Int. Whal. Comm.** 25:114-126.

Oleson, E.M., P.R. Wade, and N.C. Young. 2022. Evaluation of the Western North Pacific Distinct Population Segment of Humpback Whales as units under the Marine Mammal Protection Act. U.S. Dep. Commer., NOAA-TM-NMFS-PIFSC-124. 27 p.

Olson, P.A. 2018. Pilot whales *Globicephala melas* and *G. macrorhynchus*. p. 701-705 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Oswald, J.N., J. Barlow, and T.F. Norris. 2003. Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. **Mar. Mamm. Sci.** 19(1):20-37.

PADI. 2024. Explore diving in Manzanillo. Accessed October 2024 at https://www.padi.com/diving-in/mexico/manzanillo-bay/

Palacios, D.M. 1996. On the specimen of the ginkgo-toothed beaked whale, Mesoplodon ginkgodens, from the Galapagos Islands. **Mar. Mamm. Sci.** 12(3):444-446.

Palacios, D.M. 1999. Blue whale (Balaenoptera musculus) occurrence off the Galápagos Islands, 1978-1995. J. Cetac. Res. Manage. 1(1):41-51.

Palacios, D.M., K.M. Stafford, and F.B. Schwing. 2005. Temporal variations in blue whale acoustic detections in relation to environmental conditions in the northeastern tropical Pacific, 1996-2002. Abstr. 16th Bienn. Conf. Biol. Mar. Mamm., 12-16 Dec. 2005, San Diego, CA.

Papale, E., M. Gamba, M. Perez-Gil, V.M. Martin, and C. Giacoma. 2015. Dolphins adjust species-specific frequency parameters to compensate for increasing background noise. **PLoS ONE** 10(4):e0121711.

Parks, S.E., M. Johnson, D. Nowacek, and P.L. Tyack. 2011. Individual right whales call louder in increased environmental noise. **Biol. Lett.** 7(1):33-35.

Parks, S.E., M.P. Johnson, D.P. Nowacek, and P.L. Tyack. 2012. Changes in vocal behaviour of North Atlantic right whales in increased noise. p. 317-320 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Parks, S.E., K. Groch, P. Flores, R. Sousa-Lima, and I.R. Urazghildiiev. 2016a. Humans, fish, and whales: how right whales modify calling behavior in response to shifting background noise conditions. p. 809-813 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Parks, S.E., D.A. Cusano, A. Bocconcelli, and A.S. Friedlaender. 2016b. Noise impacts on social sound production by foraging humpback whales. Abstr. 4th Int. Conf. Effects of Noise on Aquatic Life, July 2016, Dublin, Ireland.

Payne, R. 1978. Behavior and vocalizations of humpback whales (*Megaptera* sp.). *In*: K.S. Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. MCC-77/03. Rep. from Sea Life Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington, DC.

Peng, C., X. Zhao, and G. Liu. 2015. Noise in the sea and its impacts on marine organisms. **Int. J. Environ. Res. Public Health** (12):12304-12323. http://dx.doi.org/doi:10.3390/ijerph121012304.

Pérez-Cortés H., B. Villa-Ramírez, A. Delgado-Estrella, and J. Patiño-Valencia. 2000. Familia Delphinidae. p. 597-626. In: S. Alvarez-Castañeda and J. Patton (eds). Mamíferos del Noroeste de Mexico ii. Centro de Investigaciones Biológicas. La Paz, Baja California Sur.

Perrin, W.F. 1990. Subspecies of *Stenella longirostris* (Mammalia: Cetacea, Delphinidae). **Proc. Biol. Soc. Wash.** 103(2):453-463.

Perrin, W.F. 2018a. Pantropical spotted dolphin *Stenella attenuata*. p. 676-678 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Perrin, W.F. 2018b. Spinner dolphin *Stenella longirostris*. p. 925-928 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Perrin, W.F. 2018c. Common dolphin *Delphinus delphis*. p. 205-209 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Perrin, W.F. and A.A. Hohn. 1994. Pantropical spotted dolphin *Stenella attenuat*a. p. 71-98 *In:* S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 5. The first book of dolphins. Academic Press, San Diego, CA. 416 p.

Perrin, W.F. and W.A. Walker. 1975. The rough-toothed porpoise, *Steno bredanensis*, in the eastern tropical Pacific. **J. Mammal.** 56:905-907.

Perrin, W.F., C.E. Wilson, and F.I. Archer II. 1994a. Striped dolphin *Stenella coeruleoalba* (Meyen, 1833). p. 129-159 *In:* S. H. Ridgway and R. J. Harrison (eds.), Handbook of marine mammals, Vol. 5. The first book of dolphins. Academic Press, San Diego, CA. 416 p.

Perrin, W.F., S. Leatherwood, and A. Collet. 1994b. Fraser's dolphin *Lagenodelphis hosei* Fraser, 1956. p. 225-240 *In:* S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 5. The first book of dolphins. Academic Press, London, U.K. 416 p.

Perrin, W.F., P.B. Best, W.H. Dawbin, K.C. Balcomb, R. Gambell, and G.J.B. Ross. 1973. Rediscovery of Fraser's dolphin *Lagenodelphis hosei*. **Nature** 241(5388):345-350.

Perrin, W.F., M.D. Scott, G.J. Walker, and V.L. Cass. 1985. Review of geographical stocks of tropical dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern Pacific. NOAA Tech. Rep. NMFS 28. 28 p.

Perrin, W.F., S.D. Mallette, and R.L. Brownell Jr. 2018. Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis*. p. 608-613 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: history and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. **Mar. Fish. Rev.** 61(1):7-23.

Perryman, W.L. and K. Danil. 2018. Melon-headed whale *Peponocephala electra*. p. 593-595 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Perryman, W.L., D.W.K. Au, S. Leatherwood, and T.A. Jefferson. 1994. Melon-headed whale *Peponocephala electra* Gray, 1846. p. 363-386. *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals. Volume 5. The first book of dolphins. Academic Press. 416 p.

Peterson, R.S., C.L. Hubbs, R.L. Gentry, and R.L. DeLong. 1968. The Guadalupe fur seal: habitat, behavior, population size, and field identification. **J. Mamm.** 49(4):665-675.

Philbrick, V.A., P.C. Fiedler, L.T. Balance, and D.A. Demer. 2003. Report of ecosystem studies conducted during the 2001 Oregon, California, and Washington (ORCAWALE) marine mammal survey on the research vessel *David Starr Jordan* and *McArthur*. NOAA Tech. Memo. NMFS-SWFSC-349. 50 p.

Pierson, M.O., J.P. Wagner, V. Langford, P. Birnie, and M.L. Tasker. 1998. Protection from, and mitigation of, the potential effects of seismic exploration on marine mammals. Chapter 7 *In*: M.L. Tasker and C. Weir (eds.), Proc. Seismic Mar. Mamm. Worksh., London, UK., 23–25 June 1998.

Pike, G.C. and I.B. MacAskie. 1969. Marine mammals of British Columbia. **Bull. Fish. Res. Board Can.** 171. 54 p.

Pine, M.K., K. Nikolich, B. Martin, C. Morris, and F. Juanes. 2020. Assessing auditory masking for management of underwater anthropogenic noise. **J. Acoust. Soc. Am.** 147(5):3408-3417.

Pirotta, E., R. Milor, N. Quick, D. Moretti, N. Di Marzio, P. Tyack, I. Boyd, and G. Hastie. 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. **PLoS ONE** 7(8):e42535. doi:10.1371/journal.pone.0042535.

Pirotta, E., K.L. Brookdes, I.M. Graham, and P.M. Thompson. 2014. Variation in harbour porpoise activity in response to seismic survey noise. **Biol. Lett.** 10:20131090. doi:10.1098/rsbl.2013.1090.

Pirotta, E., N.D. Merchant, P.M. Thompson, T.R. Barton, and D. Lusseau. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. **Biol. Conserv.** 181:82-98.

Pirotta, E., M. Mangel, D.P. Costa, B. Mate, J.A. Goldbogen, D.M. Palacios, L.A. Hückstädt, E.A. McHuron, L. Schwartz, and L. New. 2018. A dynamic state model of migratory behavior and physiology to assess the consequence of environmental variation and anthropogenic disturbance on marine vertebrates. **Am. Nat.** 191(2):E000-E000.

Pitman, R. 2018a. Indo-Pacific beaked whale *Indopacetus pacificus*. p. 509-512 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Pitman, R. 2018b. Mesoplodon beaked whales *Mesoploldon* spp. p. 595-602 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Pitman, R.L. and L.T. Ballance. 1992. Parkinson's petrel distribution and foraging ecology in the eastern tropical Pacific: Aspects of an exclusive feeding relationships with dolphins. **Condor** 94(4):825-835.

Pitman, R.L. and M.S. Lynn. 2001. Biological observations of an unidentified Mesoplodont whale in the eastern tropical Pacific and probable identity: *Mesoplodon peruvianus*. **Mar. Mamm. Sci.** 17(3): 648-657.

Pitman, R.L., A. Aguayo L., and J. Urbán R. 1987. Observations of an unidentified beaked whale (*Mesoplodon* sp.) in the eastern tropical Pacific. **Mar. Mamm. Sci.** 3(4):345-352.

Pitman, R.L., D.M. Palacios, P.L.R. Brennan, B.J. Brennan, K.C. Balcomb, III, and T. Miyashita. 1999. Sightings and possible identity of a bottlenose whale in the tropical Indo-Pacific: *Indopacetus pacificus*? **Mar. Mamm. Sci.** 15(2): 513-518.

Polacheck, T. 1987. Relative abundance, distribution and inter-specific relationship of cetacean schools in the Eastern Tropical Pacific. **Mar. Mamm. Sci.** 3(1):54-77.

Popov, V.V., A.Y. Supin, D. Wang, K. Wang, L. Dong, and S. Wang. 2011. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaeorientalis*. **J. Acoust. Soc. Am.** 130(1):574-584.

Popov, V.V., A.Y. Supin, V.V. Rozhnov, D.I. Nechaev, E.V. Sysuyeva, V.O. Klishin, M.G. Pletenko, and M.B. Tarakanov. 2013. Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. **J. Exp. Biol.** 216:1587-1596.

Popov, V.V., D.I. Nechaev, E.V. Sysueva, V.V. Rozhnov, and A.Y. Supin. 2015. Spectrum pattern resolution after noise exposure in a beluga whale: evoked potential study. **J. Acoust. Soc. Am.** 138(1):377-388.

Popov, V., A. Supin, D. Nechaev, E.V. Sysueva, and V. Rozhnov. 2016. Temporary threshold shifts in naïve and experienced belugas: Can dampening of the effects of fatiguing sounds be learned? p. 853-859 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Popov, V.V., A.Y. Supin, A.P. Gvozdeva, D.I. Nechaev, M.B. Tarakanov, and E.V. Sysueva. 2020. Spatial release from masking in a bottlenose dolphin *Tursiops truncatus*. **J. Acoust. Soc. Am.** 147(3):1719-1726.

Quick, N., L. Scott-Hayward, D. Sadykova, D. Nowacek, and A.J. Read. 2017. Effects of a scientific echo sounder on the behavior of short-finned pilot whales (*Globicephala macrorhynchus*). **Can. J. Fish. Aquat. Sci**. 74:716-726.

Radtke, C.L., J.M. Terhune, H. Frouin-Mouy, and P.A. Rouget. 2023. Vocal count responses of narwhals to bulk carrier noise in Milne Inlet, Nunavut, Canada. **Mar. Mamm. Sci.** 39:1057-1075.

Rako, N., C.M. Fortuna, D. Holcer, P. Mackelworth, M. Nimak-Wood, G. Pleslić, L. Sebastianutto, I. Vilibić, A. Wiemann, and M. Picciulin. 2013. Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres-LoŠinj archipelago (northern Adriatic Sea, Croatia). **Mar. Poll. Bull.** 68(1-2):77-84.

Rako-Gospić, N. and M. Picciulin. 2019. Underwater noise: Sources and effects on marine life. p. 367-389 *In:* C. Sheppard (ed.) World Seas: An Environmental Evaluation. Academic Press.

Rankin, S. and J. Barlow. 2005. Source of the North Pacific boing sound attributed to minke whales. **J. Acoust. Soc. Am**. 118:3346-3351.

Ransome, N., N.R. Loneragan, L. Medrano-González, F. Félix, and J.N. Smith. 2021. Vessel strikes of large whales in the eastern tropical Pacific: a case study of regional underreporting. **Front. Mar. Sci.** 8:675245.

Redfern, J.V., M.F. McKenna, T.J. Moore, J. Calambokidis, M.L. Deangelis, E.A. Becker, J. Barlow, K.A. Forney, P.C. Fiedler, and S.J. Chivers. 2013. Assessing the risk of ships striking large whales in marine spatial planning. **Conserv. Biol.** 27(2):292-302.

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. Guide to marine mammals of the world. Chanticleer Press, New York, NY. 525 p.

Reeves, R.R., B.D. Smith, E.A. Crespo, and G. Notarbartolo di Sciara. 2003. Dolphins, whales, and porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group, Gland, Switzerland, and Cambridge, UK.

Reichmuth, C., A. Ghoul, A. Rouse, J. Sills, and B. Southall. 2016. Low-frequency temporary threshold shift not measured in spotted or ringed seals exposed to single airgun impulses. **J. Acoust. Soc. Am.** 140(4):2646-2658.

Reilly, S.B. 1990. Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. **Mar. Ecol. Prog. Ser.** 66(1-2):1-11.

Reilly, S.B. and P.C. Fiedler. 1994. Interannual variability of dolphin habitats in the eastern tropical Pacific. I: Research vessel surveys, 1986-1990. **Fish. Bull.** 92(2):434-450.

Reilly, S.B. and V.G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. **Mar. Mamm. Sci.** 6:265-277.

Reyes, J.C. 1991. The conservation of small cetaceans: a review. Report prepared for the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals. UNEP.

Rice, D.W. 1974. Whales and whale research in the eastern North Pacific. p. 170-195 *In*: W.E. Schevill (ed.), The whale problem: a status report. Harvard Press, Cambridge, MA.

Rice, D.W. 1978. The humpback whale in the North Pacific: distribution, exploitation and numbers. p. 29-44 *In*: K.S. Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. NTIS PB 280 794, U.S. Dept. of Comm.

Rice, D.W. 1989. Sperm whale *Physeter macrocephalus* Linnaeus, 1758. p. 177-233 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.

Rice, D.W. 1998. Marine mammals of the world, systematics and distribution. Spec. Publ. 4. Soc. Mar. Mammal., Allen Press, Lawrence, KS. 231 p.

Rice, A.N., J.T. Tielens, B.J. Estabrook, C.A. Muirhead, A. Rahaman, M. Guerra, and C.W. Clark. 2014. Variation of ocean acoustic environments along the western North Atlantic coast: a case study in context of the right whale migration route. **Ecol. Inform.** 21:89-99.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego. 576 p.

Richardson, W.J., G.W. Miller, and C.R. Greene, Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. **J. Acoust. Soc. Am.** 106(4, Pt. 2):2281 (Abstr.).

Risch, D., P.J. Corkeron, W.T. Ellison, and S.M. Van Parijs. 2012. Changes in humpback whale song occurrence in response to an acoustic source 200 km away. **PLoS One** 7:e29741.

Risch, D., P.J. Corkeron, W.T. Ellison, and S.M. Van Parijs. 2014. Formal comment to Gong et al.: Ecosystem scale acoustic sensing reveals humpback whale behavior synchronous with herring spawning processes and re-evaluation finds no effect of sonar on humpback song occurrence in the Gulf of Maine in fall 2006. **PLoS One** 9(10):e109225.

Robertson, F.C., W.R. Koski, T.A. Thomas, W.J. Richardson, B. Würsig, and A.W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. **Endang. Species Res.** 21:143-160.

Rodríguez-Herrera, B., F.A. Chinchilla, and L.J. May-Collado. 2002. Lista de especies, endemismo y conservación de los de mamiferos de Costa Rica. **Rev. Mex. Mastozoologia** 6:19-41.

Rogers, P.J., C. Huveneers, B. Page, S.D. Goldsworthy, M. Coyne, A.D. Lowther, J.G. Mitchell, and L. Seuront. 2015. Living on the continental shelf edge: Habitat use of juvenile shortfin makos Isurus oxyrinchus in the Great Australian Bight, southern Australia. **Fish. Oceanogr.** 24:205-218.

Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, S.K. Water, and S.D. Kraus. 2012. Evidence that ship noise increases stress in right whales. **Proc. R. Soc. B** 279:2363-2368.

Ronald, K. and B.L. Gots. 2003. Seals: Phocidae, Otariidae, and Odobenidae. p. 789-854 *In:* G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.), Wild mammals of North America: biology, management, and conservation, 2nd ed. John Hopkins University Press, Baltimore, MD.

Rosales, M.L. and S. Escorza-Treviño. 2005. Population structure and sex biased dispersal of spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific. 2005. Abstr. 16th Bienn. Conf. Biol. Mar. Mamm., 12-16 Dec. 2005, San Diego, CA.

RPS. 2014a. Final environmental assessment for seismic reflection scientific research surveys during 2014 and 2015 in support of mapping the U.S. Atlantic seaboard extended continental margin and investigating tsunami hazards. Rep. from RPS for United States Geological Survey, August 2014. Accessed in March 2017 at http://www.nsf.gov/geo/oce/envcomp/usgssurveyfinalea2014.pdf.

RPS. 2014b. Draft protected species mitigation and monitoring report: U.S. Geological Survey 2-D seismic reflection scientific research survey program: mapping the U.S. Atlantic seaboard extended continental margin and investigating tsunami hazards, in the northwest Atlantic Ocean, Phase 1, 20 August 2014–13 September 2014, R/V *Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.

RPS. 2015. Protected species mitigation and monitoring report: East North American Margin (ENAM) 2-D seismic survey in the Atlantic Ocean off the coast of Cape Hatteras, North Carolina, 16 September–18 October 2014, R/V *Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.

Ruppel, C.D., T.C. Weber, E.R. Staaterman, S.J. Labak, and P.E. Hart. 2022. Categorizing active marine acoustic sources based on their potential to affect marine animals. **J. Mar. Sci. Eng.** 10:1278.

Rutenko, A.N., M.M. Zykov, V.A. Gritsenko, M.Y. Fershalov, M.R. Jenkerson, R. Racca, and V.E. Nechayuk 2022. Real-time acoustic monitoring with telemetry to mitigate potential effects of seismic survey sounds on marine mammals: a case study offshore Sakhalin Island. **Environ. Monit. Assess.** 194 (Suppl. 1):745.

Sairanen, E.E. 2014. Weather and ship induced sounds and the effect of shipping on harbor porpoise (*Phocoena phocoena*) activity. M.Sc. Thesis, University of Helsinki. 67 p.

Salden, D.R. 1993. Effects of research boat approaches on humpback whale behavior off Maui, Hawaii, 1989−1993. p. 94 *In*: Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993. 130 p.

Sarnocińska, J., J. Teilmann, J.D. Balle, F.M. van Beest, M. Delefosse, and J. Tougaard. 2020. Harbor porpoise (*Phocoena phocoena*) reaction to a 3D seismic airgun survey in the North Sea. **Front. Mar. Sci.** 6:824.

Savage, K. 2017. Alaska and British Columbia Large Whale Unusual Mortality Event Summary Report. NOAA Fisheries, Juneau, AK. 42 p.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2016. Temporary shift in masking hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. p. 987-991 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Scholik-Schlomer, A. 2015. Where the decibels hit the water: perspectives on the application of science to real-world underwater noise and marine protected species issues. **Acoustics Today** 11(3):36-44.

Schramm, Y., S.L. Mesnick, J. De la Rosa, D.M. Palacios, M.S. Lowry, D. Aurioles-Gamboa, H.M. Snell, and S. Escorza-Treviño. 2009. Phylogeography of California and Galápagos sea lions and population structure within the California sea lion. **Mar. Biol.** 156(7):1375-1387.

Schwarz, L.K., T. Gerrodette, and F.I. Archer. 2010. Comparison of closing and passing mode from a line-transect survey of delphinids in the eastern Tropical Pacific Ocean. **J. Cetacean Res. Manag.** 11:253-265.

Schwarz, L., E. McHuron, M. Mangel, G. Gailey, and O. Synchenko. 2022. Gray whale habitat use and reproductive success during seismic surveys near their feeding grounds: comparing state-dependent life history models and field data. **Env. Monit. Assess.** 194 (Suppl. 1):733.

Sciacca, V., S. Viola, S. Pulvirenti, G. Riccobene, F. Caruso, E. De Domenico, and G. Pavan. 2016. Shipping noise and seismic airgun surveys in the Ionian Sea: potential impact on Mediterranean fin whale. Proceedings of Meetings on Acoustics 4ENAL 27(1):040010.

Scott, M.D. and S.J. Chivers. 1990. Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. p. 387-402. *In:* S. Leatherwood and R.R. Reeves (eds.), The bottlenose dolphin. Academic Press, San Diego, CA. 653 p.

Scott, M.D., C.E. Lennert-Cody, T. Gerrodette, S.J. Chivers, K. Danil, A.A. Hohn, L.M. Duffy, R.J. Olson, H.J. Skaug, C.V. Minte-Vera, P.C. Fiedler, L.T. Ballance, K.A. Forney, J. Hofmeister, M.C. Ferguson, and J. Barlow. 2018. Data available for assessing dolphin population status in the Eastern Tropical Pacific Ocean. Special Report 23. Inter-American Tropical Tuna Commission. 30 p. Accessed March 2021 at https://www.iattc.org/PDFFiles/SpecialReports/_English/No-23-2018-Mulitiple_Data%20available%20for%20assessing%20dolphin%20population%20status%20in%20the%20ETP.pdf

Sears, R. and W.F. Perrin. 2018. Blue whale *Balaenoptera musculus*. p. 110-114 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Sergeant, D.E. 1977. Stocks of fin whales *Balaenoptera physalus* L. in the North Atlantic Ocean. **Rep. Int. Whal. Comm.** 27:460-473.

Sidorovskaia, N., B. Ma, A.S. Ackleh, C. Tiemann, G.E. Ioup, and J.W. Ioup. 2014. Acoustic studies of the effects of environmental stresses on marine mammals in large ocean basins. p. 1155 *In*: AGU Fall Meeting Abstracts, Vol. 1.

Sills, J.M., B.L. Southall, and C. Reichmuth. 2017. The influence of temporally varying noise from seismic air guns on the detection of underwater sounds by seals. **J. Acoust. Soc. Am.** 141(2):996-1008.

Sills, J.M., B. Ruscher, R. Nichols, B.L. Southall, and C. Reichmuth. 2020. Evaluating temporary threshold shift onset levels for impulsive noise in seals. **J. Acoust. Soc. Am.** 148(5):2973-2986.

Simard, Y., F. Samaran, and N. Roy. 2005. Measurement of whale and seismic sounds in the Scotian Gully and adjacent canyons in July 2003. p. 97-115 *In*: K. Lee, H. Bain, and C.V. Hurley (eds.), Acoustic monitoring and marine mammal surveys in The Gully and outer Scotian Shelf before and during active seismic surveys. Environ. Stud. Res. Funds Rep. 151. 154 p. (Published 2007).

Simmonds, M.P., S.J. Dolman, M. Jasny, E.C.M. Parsons, L. Weilgart, A.J. Wright, and R. Leaper. 2014. Marine noise pollution – Increasing recognition but need for more practical action. **J. Ocean Tech.** 9:71-90.

Sivle, L.D., T.N. Forland, R.R. Hansen, M. Andersson, E. Grimsbø, M. Linne, and H.E. Karlsen. 2017. Behavioural effects of seismic dose escalation exposure on captive mackerel (*Scomber scombrus*). Rapport Fra Havforskningen. Available at: https://imr.brage.unit.no/imr-xmlui/bitstream/handle/11250/2471924/Behavioural%2Beffects%2Bof%2Bseismic%2Bdose%2Bescalation%2Bexposure%2Bon%2Bcaptive%2Bmackerel.pdf?sequence=1

Smith, T.D. 1983. Changes in size of three dolphin (*Stenella* spp.) populations in the eastern tropical Pacific. **Fish. Bull.** 81(1):1-13.

Southall, B.L. 2021. Evolutions in marine mammal noise exposure criteria. **Acoustics Today** 17(2):52-60.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. **Aquat. Mamm.** 33(4):411-522.

Southall, B.L., T. Rowles, F. Gulland, R.W. Baird, and P.D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar. Accessed in March 2017 at http://www.agriculturedefensecoalition.org/sites/default/files/file/us_navy_new/271S_8_2013_Independent_Scientific_Review_Panel_Contributing_Factors_Mass_Whale_Stranding_Madagascar_September_25_2013_Final_Report.pdf.

Southall, B.L., D.P. Nowacek, P.J.O. Miller, and P.L. Tyack. 2016. Experimental field studies to measure behavioral responses of cetaceans to sonar. **Endang. Species Res.** 31:293-315.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. **Aquatic Mamm.** 45(2):125-232.

Southall, B.L., D.P. Nowacek, A.E. Bowles, V. Senigaglia, L. Bejder, and P.L. Tyack. 2021. Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. **Aquatic Mamm.** 47(5):421-464.

Southall, B.L., G.P. Donovan, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and D.P. Nowacek. 2023. Data collection and analysis methods to evaluate potential impacts of seismic surveys and other marine industrial activities on baleen whales. **Ocean Coastal Manage.** 245:106799.

Spiga, I. 2022. The acoustic response of snapping shrimp to synthetic impulsive acoustic stimuli between 50 and 600 Hz. **Mar. Poll. Bull.** 185:114238.

Sportelli, J.J, K.M. Heimann, and B.L. Jones. 2024. Moderate anthropogenic noise exposure does not affect Navy bottlenose dolphin (*Tursiops truncatus*) whistle rates. **J. Mar. Sci. Eng.** 12(41):2-12.

Sprogis, K.R., S. Videsen, and P.T. Madsen. 2020. Vessel noise levels drive behavioural responses of humpback whales with implications for whale-watching. **elife** 9:1-17.

Stafford, K.M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. **Mar. Mamm. Sci.** 19(4):682-693.Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 1999. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. **J. Acoust. Soc. Am.** 106(6):3687-3698.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 1999. Low-frequency whale sounds recorded on hydrophones moored in the eastern tropical Pacific. **J. Acoust. Soc. Am.** 106(6):3687-3698.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. **J. Cetac. Res. Manage.** 3(1):65-76.

Stafford, K.M., D.K. Mellinger, S.E. Moore, and C.G. Fox. 2007. Seasonal variability and detection range modeling of baleen whale calls in the Gulf of Alaska, 1999–2002. **J. Acoust. Soc. Am.** 122(6):3378-3390.

Stafford, K.M., J.J. Citta, S.E. Moore, M.A. Daher, and J.E. George. 2009. Environmental correlates of blue and fin whale call detections in the North Pacific Ocean from 1997 to 2002. **Mar. Ecol. Progr. Ser.** 395:37-53.

Steiger, G.H., J. Calambokidis, R. Sears, K.C. Balcomb, and J.C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. **Mar. Mamm. Sci.** 7(3):306-310.

Stewart, B.S. and S. Leatherwood. 1985. Minke whale *Balaenoptera acutorostrata* Lacépède, 1804. p. 91-136 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The sirenians and baleen whales. Academic Press, London, UK. 362 p.

Stewart, B.S., P.K. Yochem, R.L. DeLong, and G.A. Antonelis, Jr. 1987. Interactions between Guadalupe fur seals and California sea lions at San Nicolas and San Miguel Islands, California. p. 103-106 *In*: J.P. Croxall and R.L. Gentry (eds.), Status, biology, and ecology of fur seals. NOAA Tech. Rep. NMFS 51. National Marine Fisheries Service. 212 p.

Stone, C.J. 2015. Marine mammal observations during seismic surveys from 1994–2010. JNCC Rep. No. 463a. 64 p.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. **J. Cetac. Res. Manage.** 8(3):255-263.

Stone, C.J., K. Hall, S. Mendes, and M.L. Tasker. 2017. The effects of seismic operations in UK waters: analysis of marine mammal observer data. **J. Cetacean Res. Manage.** 16:71-85.

Supin, A., V. Popov, D. Nechaev, E.V. Sysueva, and V. Rozhnov. 2016. Is sound exposure level a convenient metric to characterize fatiguing sounds? A study in beluga whales. p. 1123-1129 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Sychenko, O., G. Gailey, R. Racca, A. Rutenko, L. Aerts, and R. Melton. 2017. Gray whale abundance and distribution relative to three seismic surveys near their feeding habitat in 2015. Abstract and presentation at the Society for Marine Mammalogy's 22nd Biennial Conference on the Biology of Marine Mammals, 22-27 October, Halifax, Nova Scotia, Canada.

Taylor, Barbara L., Karen K. Martien, Frederick I. Archer, Katherina Audley, John Calambokidis, Ted Cheeseman, Joëlle De Weerdt, Astrid Frisch Jordán, Pamela Martínez-Loustalot, Christian D. Ortega-Ortiz, Eric M. Patterson, Nicola Ransome, Penny Ruvelas, Jorge Urbán Ramírez. 2021. Evaluation of humpback whales wintering in Central America and southern Mexico as a demographically independent population. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-655.

Teilmann, J., D.M. Wisniewska, M. Johnson, L.A. Miller, U. Siebert, R. Dietz, S. Sveegaard, A. Galatius, and P.T. Madsen. 2015. Acoustic tags on wild harbour porpoises reveal context-specific reactions to ship noise. *In*: 18. Danske Havforskermøde 2015, 28-30 January 2015.

Tenessen, J.B. and S.E. Parks. 2016. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. **Endang. Species Res.** 30:225-237.

Terhune, J.M. and T. Bosker. 2016. Harp seals do not increase their call frequencies when it gets noisier. p. 1149-1153 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Tervo, O.M., S.B. Blackwell, S. Ditlevsen, A.S. Conrad, A.L. Samson, E. Garde, R.G. Hansen, and M.P. Heide-Jørgensen. 2021. Narwhals react to ship noise and airgun pulses embedded in background noise. **Biol. Lett.** 17(11):20210220.

Tervo, O.M., S.B. Blackwell, S. Ditlevsen, E. Garde, R.G. Hansen, A.L. Samson, A.S. Conrad, and M.P. Heide-Jørgensen. 2023. Stuck in a corner: Anthropogenic noise threatens narwhals in their once pristine Arctic habitat. **Sci. Adv.** 9(30):p.eade0440.

Thode, A.M., K.H. Kim, S.B. Blackwell, C.R. Greene, Jr., C.S. Nations, T.L. McDonald, and A.M. Macrander. 2012. Automated detection and localization of bowhead whale sounds in the presence of seismic airgun surveys. **J. Acoust. Soc. Am.** 131(5):3726-3747.

Thode, A.M., S.B. Blackwell, A.S. Conrad, K.H. Kim, T. Marques, L. Thomas, C.S. Oedekoven, D. Harris, and K. Bröker. 2020. Roaring and repetition: How bowhead whales adjust their call density and source level (Lombard effect) in the presence of natural and seismic airgun survey noise. **J. Acoust. Soc. Am.** 147(3):2061-2080.

Thompson, D., M. Sjöberg, E.B. Bryant, P. Lovell, and A. Bjørge. 1998. Behavioural and physiological responses of harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals to seismic surveys. Abstr. World Mar. Mamm. Sci. Conf., Monaco.

Thompson, P.M., K.L. Brookes, I.M. Graham, T.R. Barton, K. Needham, G. Bradbury, and N.D. Merchant. 2013. Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. **Proc. Royal Soc. B** 280: 20132001.

Tougaard, J., A.J. Wright, and P.T. Madsen. 2015. Cetacean noise criteria revisited in light of proposed exposure limits for harbour porpoises. **Mar. Poll. Bull.** 90(1-2):196-208.

Tougaard, J., A.J. Wright, and P.T. Madsen. 2016. Noise exposure criteria for harbor porpoises. p. 1167-1173 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Tougaard, J., K. Beedholm, and P.T. Madsen. 2022. Thresholds for noise induced hearing loss in harbor porpoises and phocid seals. **J. Acoust. Soc. Am.** 151:4252-4263.

Tougaard, J., K. Beedholm, and P.T. Madsen. 2023. Temporary threshold shift in porpoise hearing effect of experimental protocol. *In:* A.N. Popper, J. Sisneros, A.D. Hawkins, and F. Thomsen (eds.) The Effects of Noise on Aquatic Life. Springer Nature, Switzerland. 500 p. doi:10.1007/978-3-031-10417-6_166-1

Trigg, L.E., F. Chen, G.I. Shapiro, S.N. Ingram, C. Vincent, D. Thompson, D.J. Russell, M.I. Carter, and C.B. Embling. 2020. Predicting the exposure of diving grey seals to shipping noise. **J. Acoust. Soc. Am.** 148(2):1014-1029.

Tyack, P.L. and V.M. Janik. 2013. Effects of noise on acoustic signal production in marine mammals. p. 251-271 *In*: H. Brumm (ed.), Animal communication and noise. Springer, Berlin, Heidelberg, Germany. 453 p.

Tyack, P.L. and L. Thomas. 2019. Using dose-response functions to improve calculations of the impact of anthropogenic noise. **Aquatic Conserv. Mar. Freshw. Ecosyst.** 29(S1):242-253.

UNEP-WCMC. 2024. Convention on International Trade in Endangered Species of Wild Flora and Fauna. Appendices I, II, and III. Accessed in October 2024 at https://www.cites.org/eng/app/appendices.php.

Urbán J. 2008. Conocimiento biológico de las especies de mamíferos marinos incluidas en la Norma Oficial Mexicana NOM-059-SEMARNAT-2001. Bases de datos SNIB-CONABIO (Comisión Nacional para el Uso y Conocimiento de la Biodiversidad). Proyecto No. CK009. México, D.F. Accessed October 2024 at http://www.conabio.gob.mx/institucion/proyectos/resultados/CK009_Fichas%20de%20Especies.pdf.

Urbán, R.J. and A.L. Aguayo. 1987. Spatial and seasonal distribution of the humpback whale, *Megaptera novaeangliae*, in the Mexican Pacific. **Mar. Mamm. Sci.** 3(4):333-344.

Urbán, R.J., A. Jaramillo L., A. Aguayo L., P. Ladrón de Guevara P., M. Salinas Z., C. Alvarez F., L. Medrano G., J.K. Jacobsen, K.C. Balcomb, D.E. Claridge, J. Calambokidis, G.H. Steiger, J.M Straley, O. von Ziegesar, J.M. Waite, S. Mizroch, M.E. Dahlheim, J.D. Darling, and C.S. Baker. 2000. Migratory destinations of humpback whales wintering in the Mexican Pacific. **J. Cetac. Res. Manage.** 2(2):101-110.

Urbán-Ramírez, J. and D. Aurioles-Gamboa. 1992. First record of the pygmy beaked whale *Mesoplodon peruvianus* in the North Pacific. **Mar. Mamm. Sci.** 8(4):420-425.

USGS (United States Geological Survey). 2013. Record of Decision for Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for marine seismic research funded by the National Science Foundation or conducted by the USGS. February 2013. 36 p. Available at https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/FINAL_USGSROD_textonly_signed27Feb2013.pdf

Van Beest, F.M., J. Teilmann, L. Hermannsen, A. Galatius, L. Mikkelsen, S. Sveegaard, J.D. Balle, R. Dietz, and J. Nabe-Nielsen. 2018. Fine-scale movement responses of free-ranging harbour porpoises to capture, tagging and short-term noise pulses from a single airgun. **R. Soc. Open Sci.** 5:170110.

Van Cise, A.M., P.A. Morin, R.W. Baird, A.R. Lang, K.M. Robertson, S.J. Chivers, R.L. Brownell, Jr., and K.K. Martien. 2016. Redrawing the map: mt DNA provides new insight into the distribution and diversity of short-finned pilot whales in the Pacific Ocean. **Mar. Mamm. Sci.** 32(4):1177-1199.

Van Waerebeek, K. and J.C. Reyes. 1988. First record of the pygmy killer whale, *Feresa attenuata* Gray, 1975 from Peru, with a summary of distribution in the eastern Pacific. **Z. Säugetierkunde** 53:253-255.

Varghese, H.K., J. Miksis-Olds, E. Linder, L. Mayer, D. Moretti, and N. DiMarzio. 2019. Effect of multibeam mapping activity on beaked whale foraging in southern California. Poster presented at the 2019 Effects of Noise on Aquatic Life conference, Den Haag, The Netherlands, July 7-12, 2019.

Varghese, H.K., J. Miksis-Olds, N. DiMarzio, K. Lowell, E. Linder, L. Mayer, and D. Moretti. 2020. The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's beaked whales off of southern California. **J. Acoust. Soc. Am.** 147(6):3849-3858.

Varghese, H.K., K. Lowell, J. Miksis-Olds, N. DiMarzio, D. Moretti, and L. Mayer. 2021. Spatial analysis of beaked whale foraging during two 12 kHz multibeam echosounder surveys. **Front. Mar. Sci.** 8:654184.

Vazzana, M., M. Mauro, M. Ceraulo, M. Dioguardi, E. Papale, S. Mazzola, V. Arizza, F. Beltrame, L. Inguglia, and G. Buscaino. 2020. Underwater high frequency noise: Biological responses in sea urchin *Arbacia lixula* (Linnaeus, 1758). **Comp. Biochem. Physiol. Part A: Mol. Integ. Physiol.** 242:110650.

Veirs, S., V. Veirs, and J.D. Wood. 2016. Ship noise extends to frequencies used for echolocation by endangered killer whales. **PeerJ.** 4:p.e1657.

Vilela, R., U. Pena, R. Esteban, and R. Koemans. 2016. Bayesian spatial modeling of cetacean sightings during a seismic acquisition survey. **Mar. Poll. Bull.** 109(1):512-520.

Wade, P.R. 1995. Revised estimates of incidental kill of dolphins (Delphinidae) by the purse-seine tuna fishery in the eastern tropical Pacific, 1959−1972. **Fish. Bull.** 93:345-354.

Wade, P.R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the Eastern Tropical Pacific. **Rep. Int. Whal. Comm.** 43:477-493.

Wade, P.R., G.M. Watters, T. Gerrodette, and S.B. Reilly. 2007. Depletion of spotted and spinner dolphins in the eastern tropical Pacific: modeling hypotheses for their lack of recovery. **Mar. Ecol. Prog. Ser.** 343:1-14.

Wade, P.R., E.M. Oleson, and N.C. Young. 2021. Evaluation of Hawai'i distinct population segment of humpback whales as units under the Marine Mammal Protection Act. U.S. Dep. Commerc., NOAA Tech. Memo. NMFS-AFSC-430. 31 p.

Walker, J.L., C.W. Potter, and S.A. Macko. 1999. The diets of modern and historic bottlenose dolphin populations reflected through stable isotopes. **Mar. Mamm. Sci.** 15(2):335-350.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. **Mar. Technol. Soc. J.** 37(4):6-15.

Watkins, W.A., M.A. Daher, G.M. Reppucci, J.E. George, D.L. Martin, N.A. DiMarzio, and D.P. Gannon. 2000a. Seasonality and distribution of whale calls in the North Pacific. **Oceanography** 13:62-67.

Watkins, W.A., J.E. George, M.A. Daher, K. Mullin, D.L. Martin, S.H. Haga, and N.A. DiMarzio. 2000b. Whale call data from the North Pacific, November 1995 through July 1999: occurrence of calling whales and source locations from SOSUS and other acoustic systems. Tech. Rep. WHOI-00-02. Woods Hole Oceanographic Inst., Woods Hole, MA. 160 p.

Weilgart, L.S. 2007. A brief review of known effects of noise on marine mammals. **Int. J. Comp. Psychol.** 20:159-168.

Weilgart, L.S. 2014. Are we mitigating underwater noise-producing activities adequately? A comparison of Level A and Level B cetacean takes. Working pap. SC/65b/E07. Int. Whal. Comm., Cambridge, UK. 17 p.

Weilgart, L. 2017. Din of the deep: noise in the ocean and its impacts on cetaceans. Pages 111-124 *In*: A. Butterworth (ed.), Marine mammal welfare human induced change in the marine environment and its impacts on marine mammal welfare. Springer.

Weilgart, L.S. 2023. Ocean noise pollution. p. 153-160 *In*: F. Obaidullah (ed.), The Ocean and Us. Springer.

Weir, C.R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. **Aquatic Mammals** 34(1):71-83.

Weir, C.R. and S.J. Dolman. 2007. Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. **J. Int. Wildl. Law Policy** 10(1):1-27.

Weise, M.J., D.P. Costa, and R.M. Kudela. 2006. Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005 compared to those of 2004. **Geophys. Res. Lett.** 33, L22S10.

Weller, D.W., Y.V. Ivashchenko, G.A. Tsidulko, A.M. Burdin, and R.L. Brownell, Jr. 2002. Influence of seismic surveys on western gray whales off Sakhalin Island, Russia in 2001. Paper SC/54/BRG14, IWC, Western Gray Whale Working Group Meet., 22-25 Oct., Ulsan, South Korea. 12 p.

Weller, D.W., S.H. Rickards, A.L. Bradford, A.M. Burdin, and R.L. Brownell, Jr. 2006a. The influence of 1997 seismic surveys on the behavior of western gray whales off Sakhalin Island, Russia. Paper SC/58/E4 presented to the IWC Scient. Commit., IWC Annu. Meet., 1-13 June, St. Kitts.

Weller, D.W., G.A. Tsidulko, Y.V. Ivashchenko, A.M. Burdin, and R.L. Brownell, Jr. 2006b. A re-evaluation of the influence of 2001 seismic surveys on western gray whales off Sakhalin Island, Russia. Paper SC/58/E5 presented to the IWC Scient. Commit., IWC Annu. Meet., 1-13 June, St. Kitts.

Wells, R.S. and M.D. Scott. 2018. Bottlenose dolphin, *Tursiops truncates*, common bottlenose dolphin. p. 118-124 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd ed. Academic Press/Elsevier, San Diego, CA. 1157 p.

Wensveen, P.J., L.A.E. Huijser, L. Hoek, and R.A. Kastelein. 2014. Equal latency contours and auditory weighting functions for the harbour porpoise (*Phocoena phocoena*). **J. Exp. Biol.** 217(3):359-369.

Wensveen, P.J., A.M. von Benda-Beckmann, M.A. Ainslie, F.P.A. Lam, P.H. Kvadsheim, P.L. Tyack, and P.J.O. Miller. 2015. How effectively do horizontal and vertical response strategies of long-finned pilot whales reduce sound exposure from naval sonar? **Mar. Environ. Res.** 106:68-81.

Whitehead, H. 2018. Sperm whale *Physeter macrocephalus*. p. 919-925 *In:* B. Würsig, J.G.M. Thewissen, and K.M. Kovacs (eds.), Encyclopedia of Marine Mammals, 3rd Edition. Academic Press/Elsevier, San Diego, CA. 1157 p.

Wiley, D.N., C.A. Mayo, E.M. Maloney, and M.J. Moore. 2016. Vessel strike mitigation lessons from direct observations involving two collisions between noncommercial vessels and North Atlantic right whales (*Eubaleana glacialis*). **Mar. Mammal Sci.** 32(4):1501-1509.

Williams, R., E. Ashe, L. Yruretagoyena, N. Mastick, M. Siple, J. Wood, R. Joy, R. Langrock, S. Mews, and E. Finne. 2021. Reducing vessel noise increases foraging in endangered killer whales. **Mar. Poll. Bull.** 173:112976.

Williams, T.M, W.A. Friedl, M.L. Fong, R.M. Yamada, P. Sideivy, and J.E. Haun. 1992. Travel at low energetic cost by swimming and wave-riding bottlenose dolphins. **Nature** 355(6363):821-823.

Williams, T.M., S.B. Blackwell, O. Tervo, E. Garde, M.H.S. Sinding, B. Richter, and M.P. Heide-Jørgensen. 2022. Physiological responses of narwhals to anthropogenic noise: a case study with seismic airguns and vessel traffic in the Arctic. **Funct. Ecol.** 36:2251-2266.

Willis, K.L., J. Christensen-Dalsgaard, D.R. Ketten, and C.E. Carr. 2013. Middle ear cavity morphology is consistent with an aquatic origin for testudines. **PLoS One** 8(1):e54086.

Winn, H.E. and N.E. Reichley. 1985. Humpback whale *Megaptera novaeangliae* (Borowski, 1781). p. 241-273 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The sirenians and baleen whales. Academic Press, London, UK. 362 p.

Winsor, M.H., L.M. Irvine, and B.R. Mate. 2017. Analysis of the spatial distribution of satellite-tagged sperm whales (*Physeter macrocephalus*) in close proximity to seismic surveys in the Gulf of Mexico. **Aquatic Mamm.** 43(4):439-446.

Wisniewska, D.M., M. Johnson, J. Teilmann, U. Siebert, A. Galatius, R. Dietz, and P.T. Madsen. 2018. High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). **Proc. R. Soc. B** 285:20172314.

Wittekind, D., J. Tougaard, P. Stilz, M. Dähne, K. Lucke, C.W. Clark, S. von Benda-Beckmann, M. Ainslie, and U. Siebert. 2016. Development of a model to assess masking potential for marine mammals by the use of airguns in Antarctic waters. p. 1243-1249 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life II. Springer, New York, NY. 1292 p.

Wole, O.G. and E.F. Myade. 2014. Effect of seismic operations on cetacean sightings off-shore Akwa Ibom State, south-south, Nigeria. **Int. J. Biol. Chem. Sci.** 8(4):1570-1580.

Wright, A.J. 2014. Reducing impacts of human ocean noise on cetaceans: knowledge gap analysis and recommendations. 98 p. World Wildlife Fund Global Arctic Programme, Ottawa, ON.

Wright, A.J. and A.M. Consentino. 2015. JNCC guidelines for minimizing the risk of injury and disturbance to marine mammals from seismic surveys: we can do better. **Mar. Poll. Bull.** 100(1):231-239.

Wright, A.J., T. Deak, and E.C.M. Parsons. 2011. Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. **Mar. Poll. Bull.** 63(1-4):5-9.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. **Aquatic Mamm.** 24(1):41-50.

Würsig, B.G., D.W. Weller, A.M. Burdin, S.H. Reeve, A.L. Bradford, S.A. Blokhin, and R.L. Brownell, Jr. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July–October 1997. A joint U.S.-Russian scientific investigation. Final Report. Rep. from Texas A&M Univ., College Station, TX, and Kamchatka Inst. Ecol. & Nature Manage., Russian Acad. Sci., Kamchatka, Russia, for Sakhalin Energy Investment Co. Ltd. and Exxon Neftegaz Ltd., Yuzhno-Sakhalinsk, Russia. 101 p.

Yang, L., X. Xu, and P. Berggren. 2022. Spotted seal *Phoca largha* underwater vocalisations in relation to ambient noise. **Mar. Ecol. Prog. Ser.** 683:209-220.

Yang, W.C., C.F. Chen, Y.C. Chuah, C.R. Zhuang, I.H. Chen, T.A. Mooney, J. Stott, M. Blanchard, I.F. Jen, and L.S. Chou. 2021. Anthropogenic sound exposure-induced stress in captive dolphins and implications for cetacean health. **Front. Mar. Sci.** 8:606736.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, S.K. Meier, H.R. Melton, M.W. Newcomer, R.M. Nielson, V.L. Vladimirov, and P.W. Wainwright. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):45-73. doi:10.1007/s10661-007-9809-9.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, and M.W. Newcomer. 2007b. Feeding activity of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess**. 134(1-3): 93-106.

Yochem, P.K. and S. Leatherwood. 1985. Blue whale. p. 193-240 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The sirenians and baleen whales. Academic Press, New York, NY. 362 p.

Yurk, H., C. O'Neill L.S. Quayle, S. Vagle, X. Mouy, M. Austing, J. Wladichuk, C. Morrison, and W.T. LeBlond. 2023. Adaptive call design to escape masking while preserving complex social functions of calls in killer whales. *In:* A.N. Popper, J. Sisneros, A.D. Hawkins, and F. Thomsen (eds.) The Effects of Noise on Aquatic Life. Springer Nature, Switzerland. 500 p. doi:10.1007/978-3-031-10417-6_187-1

Zerbini, A.N., A. Andriolo, M.-P. Heide-Jørgensen, S.C. Moreira, J.L. Pizzorno, Y.G. Maia, G.R. VanBlaricom, and D.P. DeMaster. 2011. Migration and summer destinations of humpback whale (*Megaptera novaeangliae*) in the western South Atlantic Ocean. **J. Cetac. Res. Manage. (Spec. Iss.)** 3:113-118.

List of Appendices

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for Level A and Level B (160 dB re 1µPa$_{rms}$) thresholds. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS) as a function of distance from the 36-airgun array, two 45/105 in^3 GI airguns, and for a single 1900LL 40-in^3 airgun. Models for the 36-airgun array and 40-in^3 airgun used a 12-m tow depth, whereas the model for the two GI airguns used a 3-m tow depth. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

Typically, for deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those GoM sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m (Costa and Williams 1999). Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

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

The proposed surveys would acquire data with the 2-GI airgun array at a maximum tow depth of 3 m in deep water. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. A-1).

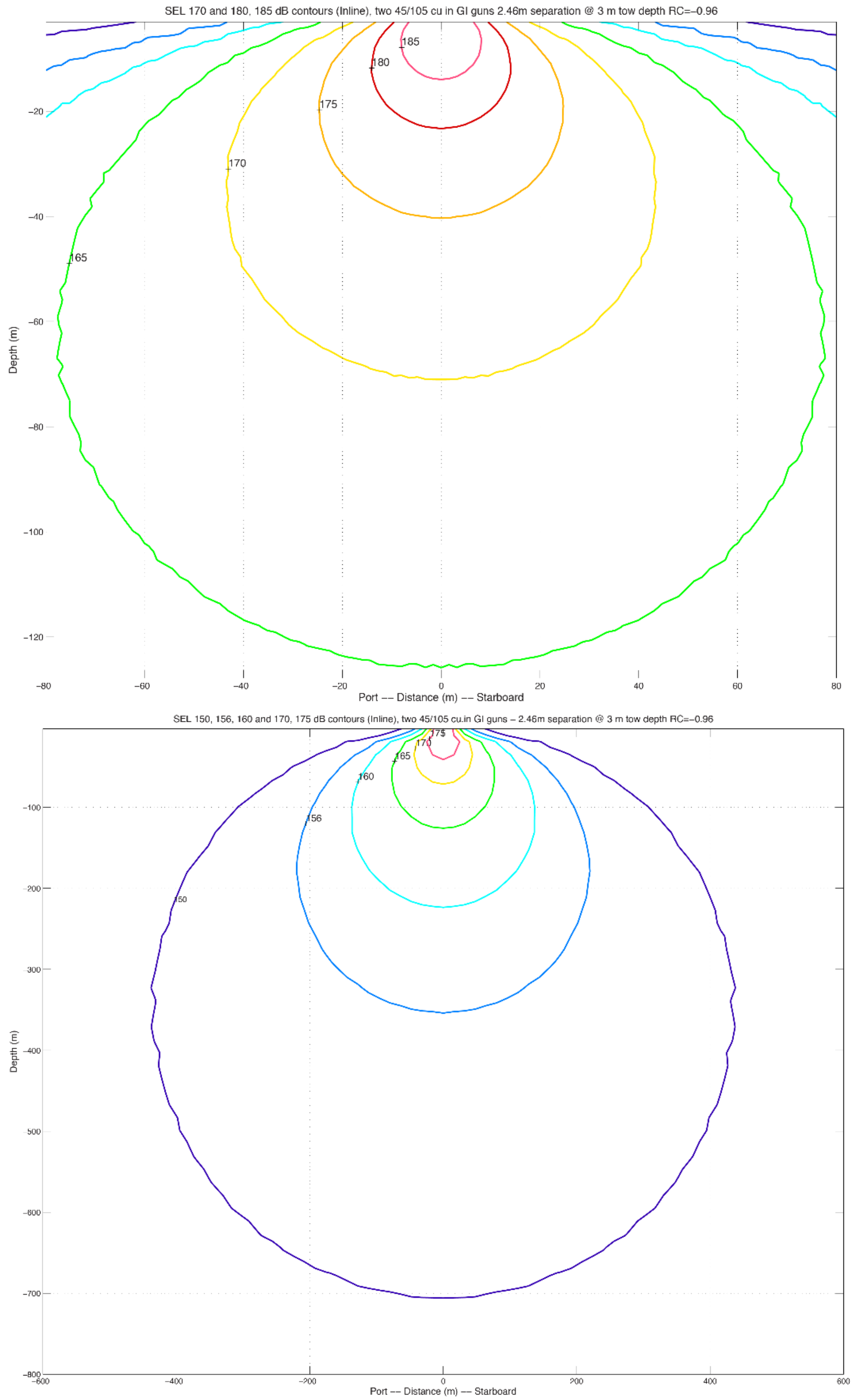

FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the two 45/105 in^3 GI airguns at a 3-m tow depth planned for use during the proposed surveys in the ETP. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

A retrospective analysis of acoustic propagation of R/V *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for R/V *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by R/V *Langseth* hydrophone streamer were 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[2] have confirmed that the L-DEO model generated conservative EZs, resulting in significantly larger EZs than required by National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

In July 2016, NMFS released technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016, 2018). The guidance established thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The noise exposure criteria for marine mammals accounted for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). For impulsive sources, onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL_{cum} and SPL_{flat}, respectively. Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016, 2018), but included all marine mammals (including sirenians), and a re-classification of hearing groups. NMFS (2024) incorporated Southall et al. (2019) recommendations into updated guidance regarding noise exposure criteria. The new guidance incorporates marine mammal auditory weighting functions (Fig. A-2) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}).

Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), high-frequency (HF) cetaceans (e.g., most delphinids), very high-frequency (VHF) cetaceans (e.g., porpoise and *Kogia* spp.), phocid pinnipeds underwater (PW), and otariid pinnipeds underwater (OW). The largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances. The dual criteria for sea turtles (DoN 2017) were also used here. The new NMFS guidance did not alter the current threshold, 160 dB re $1\mu Pa_{rms}$, for Level B harassment (behavior). It should be recognized that there are a number of limitations and uncertainties associated with these injury criteria (Southall et al. 2007). Lucke et al. (2020) caution that some current thresholds may not be able to accurately predict hearing impairment and other injury to marine mammals due to noise.

Table A-1 shows the distances at which the 160-dB and 175-dB re $1\mu Pa_{rms}$ sound levels are expected to be received for the 2-GI airgun array. The 160-dB level is the behavioral disturbance criteria (Level B) that is used by NMFS to estimate anticipated takes for marine mammal. The 175-dB level is used by NMFS, based on data from the DoN (2017), to determine behavioral disturbance for turtles.

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

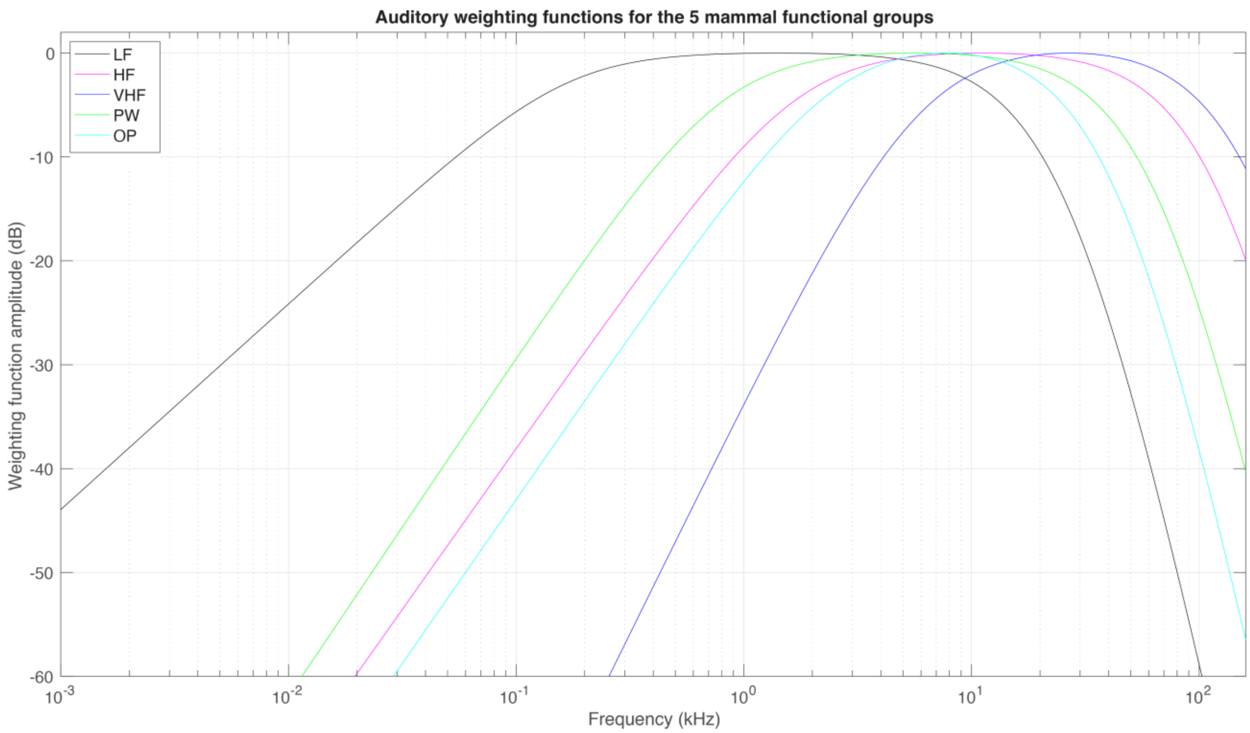

FIGURE A-2. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet. LF = low frequency cetaceans, HF = high frequency cetaceans, VHF = very high frequency cetaceans, PW = phocid pinnipeds underwater, OP = otariid pinnipeds underwater.

Table A-5. Predicted distances to behavioral disturbance sound levels ≥160-dB re 1 μPa_{rms} and ≥175-dB re 1 $\mu Pa_{rm}s$ that could be received during the proposed surveys in the ETP off Mexico, based on modeling. The 160-dB criterion applies to all hearing groups of marine mammals (Level B harassment), and the 175-dB criterion applies to sea turtles.

Source and Volume	**Tow Depth[1] (m)**	**Water Depth (m)**	**Predicted distances (in m) to the 160-dB Received Sound Level[2]**	**Predicted distances (in m) to the 175-dB Received Sound Level[2]**
Two 45/105 in^3 GI airguns	3	>1000 m	438	78

The radii for intermediate water depths (100–1000 m) are typically derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS). However, no effort would occur in intermediate or shallow water during the proposed surveys.

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

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

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on overriding the default values and calculating individual adjustment factors (dB) based on the modified farfield and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (source velocity and duty) after Sivle et al. (2014). A source velocity of 2.315 m/s and a 1/Repetition rate of 2.93 s (based on a shot interval of 6.25 m at a speed of 4.5 kts) were used as inputs to the NMFS User Spreadsheet for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the 2- GI airguns. This input provided more conservative values than using the larger shot interval of 12 m and speed of 5 kts.

For the LF cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183 dB SEL_{cum} isopleth is located at 13.44 m from the source. We then run the modeling for one single shot with the LF cetaceans weighting function applied to the full spectrum. The maximum 183 dB SELcum isopleth is located at 8.2467 m from the source. The difference between 13.44 m and 8.2467 m gives an adjustment factor of 4.2445 dB assuming a propagation of 20log10(R) (Table A-2).

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

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

SEL_{cum} Threshold	183	193	159	183	185
Radial Distance (m) (no weighting function)	13.4432	3.6807	221.7287	13.4432	9.597
Modified Farfield SEL	205.5701	204.3186	205.9164	205.5701	205.1005
Radial Distance (m) (with weighting function)	8.2467	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-4.2445	N.A.	N.A.	N.A.	N.A.

N.A. is not applicable.

For the 2-GI airgun array, the results for single shot SEL source level modeling are shown in Table A-2. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 2 GI airguns are shown in Table A-3. Figure A-3 shows the impact of weighting functions by hearing group. Figures A-4–A-5 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-6 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

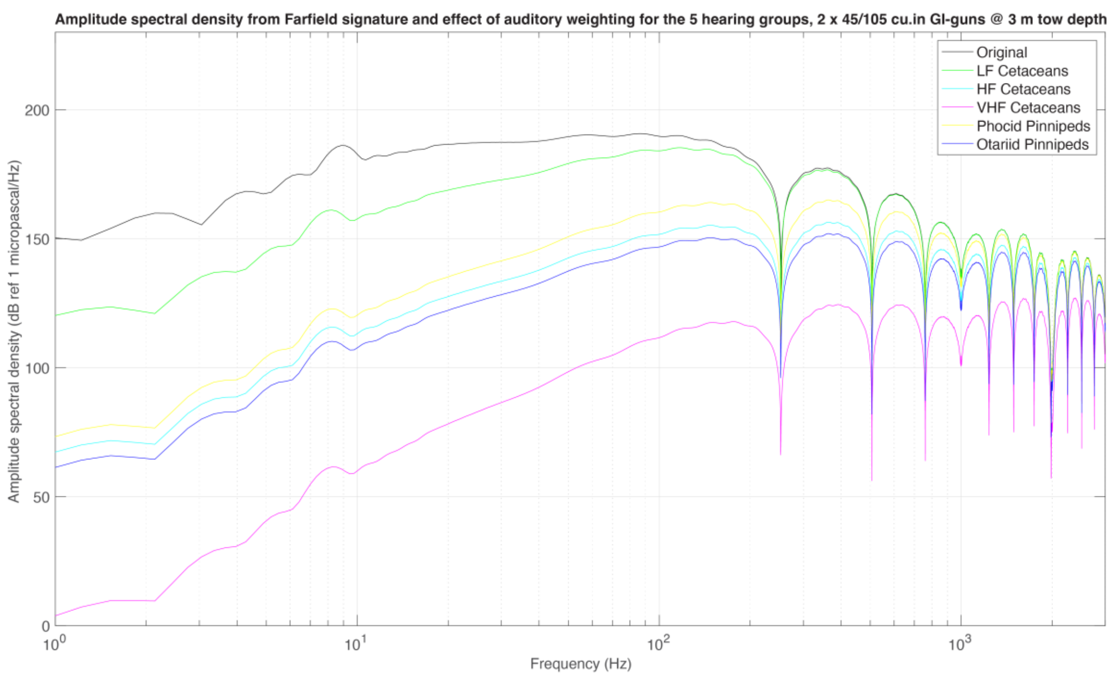

FIGURE A-3. Modeled amplitude spectral density of the two 45/105 in^3 airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, HF, and VHF cetaceans, as well as Phocid Pinnipeds Underwater (PW), and Otariid Pinnipeds Underwater (OW). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE A-3. Results for single shot SEL source level modeling for the 2-GI airgun array with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various hearing groups.

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Spinelli/Worthington (Mexico)
PROJECT/SOURCE INFORMATION	source : SIO portable system = 2 x 45/105 cu.in GI-gun at a 3m towed depth
Please include any assumptions	
PROJECT CONTACT	

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

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

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

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

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

STEP 3: SOURCE-SPECIFIC INFORMATION

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

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

SEL_{cum}

Source Velocity (meters/second)	2.315
1/Repetition rate^ (seconds)	2.93

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

^Time between onset of successive pulses.

Modified farfield SEL	205.5701	204.3186	205.91645	205.5701	205.1005
Source Factor	1.23067E+20	9.22555E+19	1.33284E+20	1.23067E+20	1.10454E+20

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

Hearing Group	Low-Frequency Cetaceans	High-Frequency Cetaceans	Very High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	193	159	183	185
AUD INJ SEL_{cum} Isopleth to threshold (meters)	**31.5**	**0.0**	**0.1**	**0.5**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	High-Frequency Cetaceans	Very High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	0.99	1.55	2.23	1.63	1.58	
b	5	5	5	5	5	
f_1	0.168	1.73	5.93	0.81	2.53	
f_2	26.6	129	186	68.3	43.8	
C	0.12	0.32	0.91	0.29	1.37	
Adjustment (dB)†	**-4.24**	**-30.12**	**-55.93**	**-22.24**	**-34.09**	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of 20*$\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure A-3).

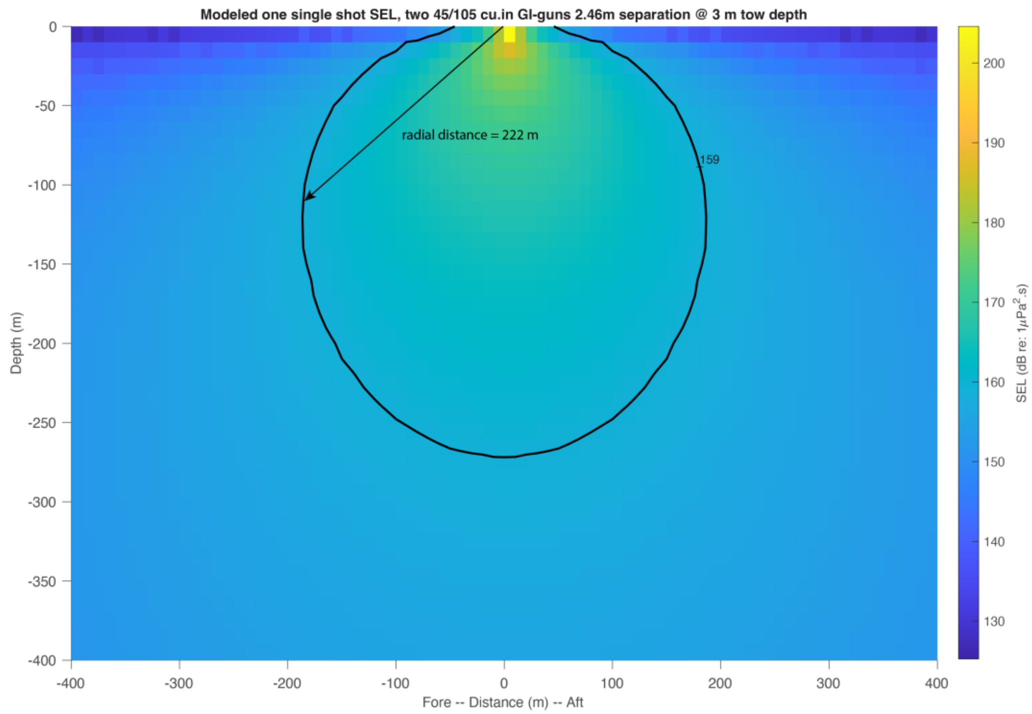

FIGURE A-4. Modeled received sound levels (SELs) in deep water from the two 45/105 in³ GI-airguns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 159-dB SEL isopleth.

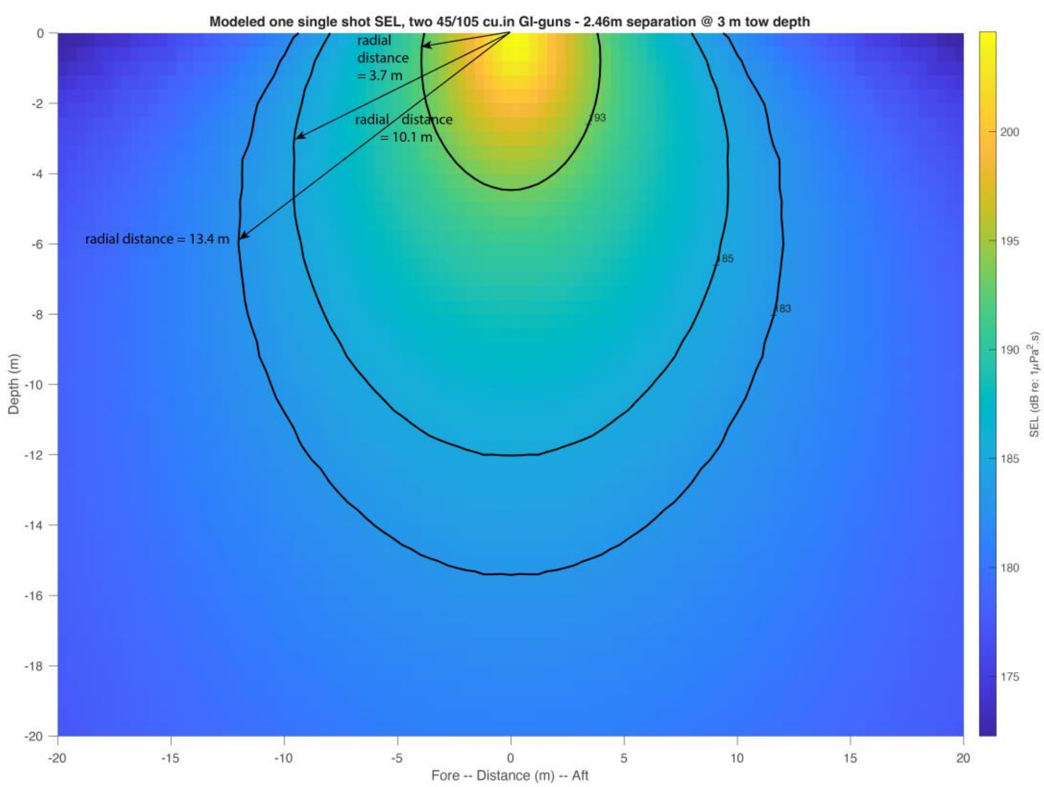

FIGURE A-5. Modeled received sound levels (SELs) in deep water from the two 45/105 in^3 GI-airguns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183, 185 and 193 dB SEL isopleths

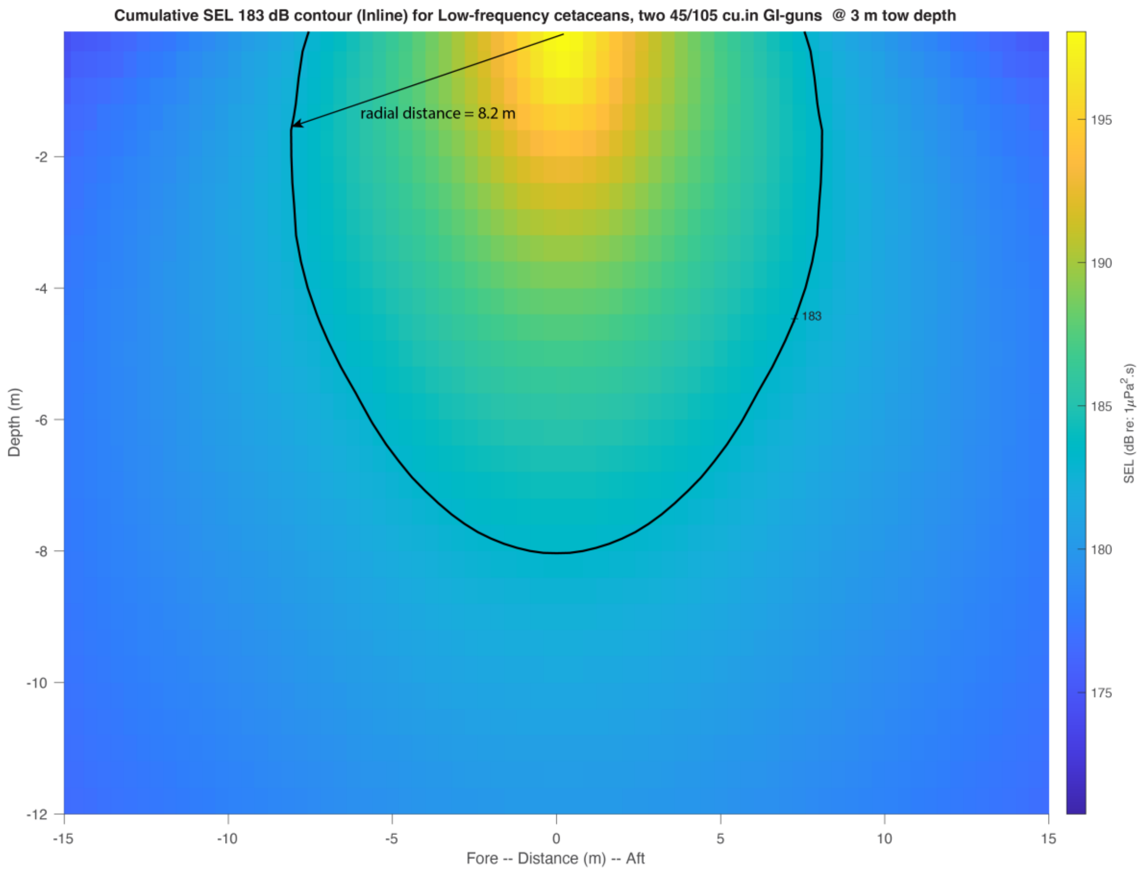

FIGURE A-6. Modeled received sound exposure levels (SELs) from the two 45/105 in^3 GI-airguns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following the new technical guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. 5 and this figure (8.2 m) allows us to estimate the adjustment in dB.

The thresholds for Peak SPL_{flat} for the 2 GI airgun array, as well as the distances to the PTS thresholds, are shown in Table A-4. Figures A-7–A-9 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

TABLE A-4. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and sea turtles and predicted distances to Level A thresholds for various hearing groups that could be received from the two 45 in^3 airgun array during the proposed surveys.

Hearing Group	**Low-Frequency Cetaceans**	**High Frequency Cetaceans**	**Very High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
Peak Threshold	**222**	**230**	**202**	**223**	**230**
Radial Distance to Threshold (m)	3.9	1.1	35.3	3.4	1.1

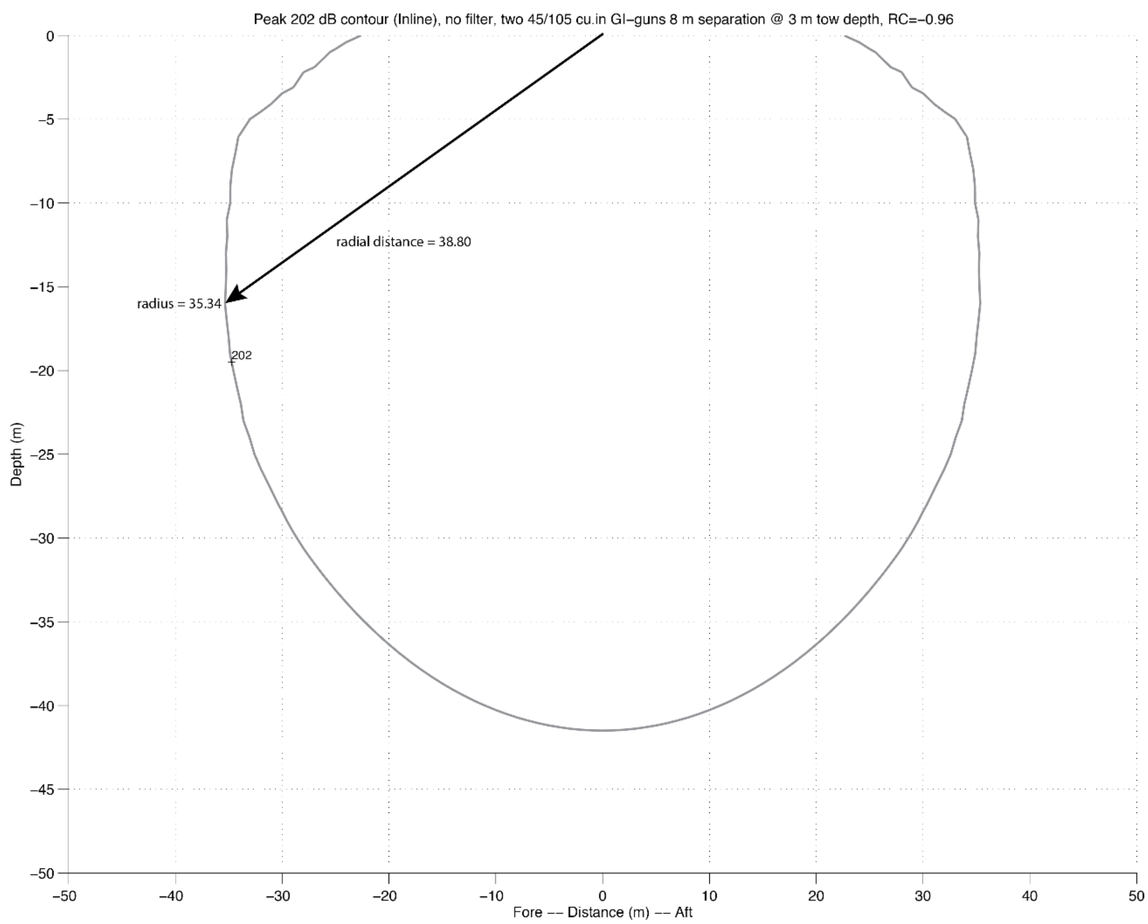

FIGURE A-7. Modeled deep-water received Peak SPL from the two 45 in^3 GI-airgun array at a 3-m tow depth. The plot provides the radial distance to the 202-dB Peak isopleth.

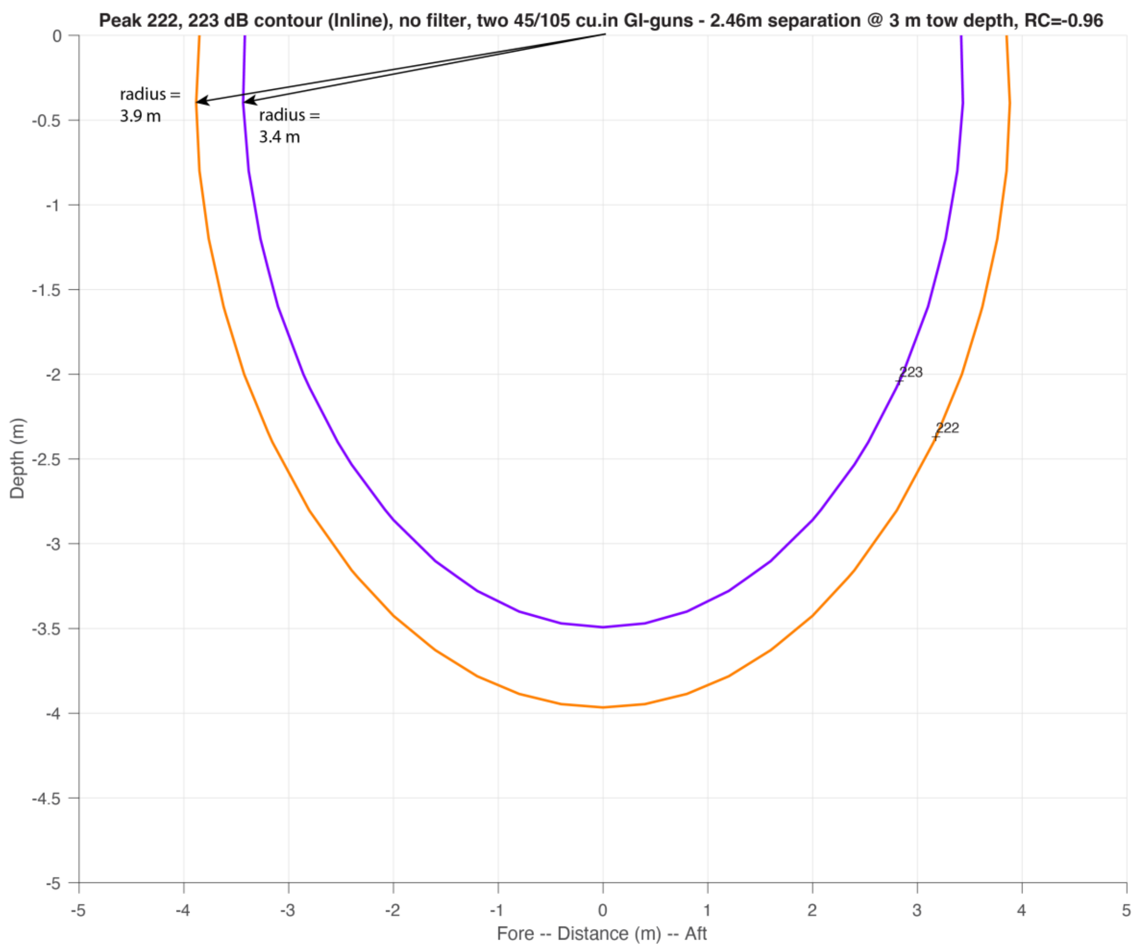

FIGURE A-8. Modeled deep-water received Peak SPL from two 45 in³ GI-airgun array at a 3-m tow depth. The plot provides the radii to the 222 and 223 dB peak isopleths.

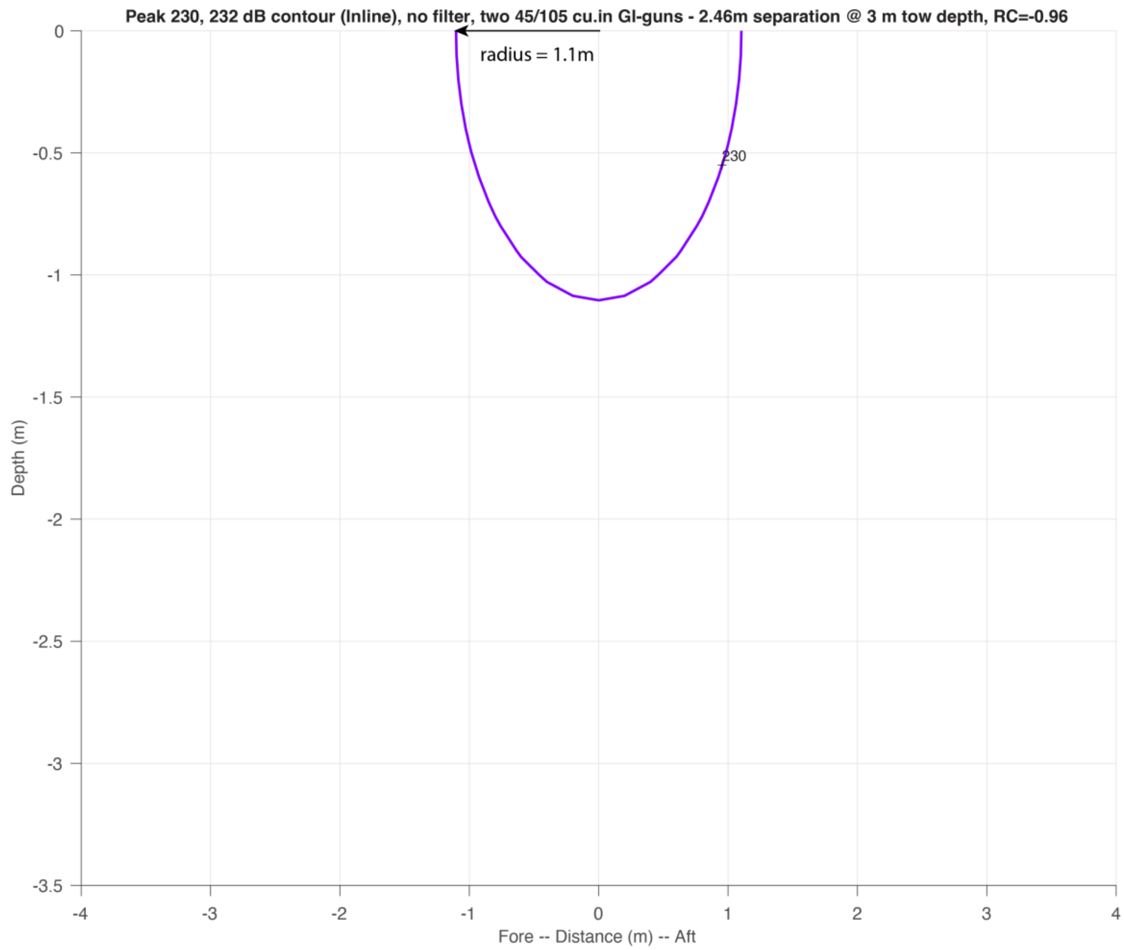

FIGURE A-9. Modeled deep-water received Peak SPL from two 45 in^3 GI-airgun array at a 3-m tow depth. The plot provides the radius to the 230 dB peak isopleths.

Literature Cited

Barton, P., J. Diebold, and S. Gulick. 2006. Balancing mitigation against impact: a case study from the 2005 Chicxulub seismic survey. **Eos Trans. Am. Geophys. Union** 87(36), Joint Assembly Suppl., Abstr. OS41A-04. 23–26 May, Baltimore, MD.

Costa, D.P. and T.M. Williams. 1999. Marine mammal energetics. p. 176-217 *In:* J.E. Reynolds III and S.A. Rommel (eds.), Biology of marine mammals. Smithsonian Institution Press, Washington. 578 p.

Crone, T.J., M. Tolstoy, and H. Carton. 2014. Estimating shallow water sound power levels and mitigation radii for the R/V *Marcus G. Langseth* using an 8 km long MCS streamer. **Geochem., Geophys., Geosyst.** 15(10):3793-3807.

Crone, T.J., M. Tolstoy, and H. Carton. 2017. Utilizing the R/V *Marcus G. Langseth*'s streamer to measure the acoustic radiation of its seismic source in the shallow waters of New Jersey's continental shelf. **PloS ONE** 12(8):e0183096.

Diebold, J.B., M. Tolstoy, P.J. Barton, and S.P. Gulick. 2006. Propagation of exploration seismic sources in shallow water. **Eos Trans. Amer. Geophys. Union** 87(36), Joint Assembly Suppl., Abstr. OS41A-03. 23–26 May, Baltimore, MD.

Diebold, J.B., M. Tolstoy, L. Doermann, S.L. Nooner, S.C. Webb, and T.J. Crone. 2010. R/V *Marcus G. Langseth* seismic source: modeling and calibration. **Geochem. Geophys. Geosyst.** 11(12):Q12012.

DoN (U.S. Department of the Navy). 2017. Criteria and thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Technical Report prepared by the U.S. Navy.

Lucke, K., S.B. Martin, and R. Racca. 2020. Evaluating the predictive strength of underwater noise exposure criteria for marine mammals. **J. Acoust. Soc. Am.** 147:3985.

NMFS. 2016. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: underwater acoustic thresholds for onset of permanent and temporary threshold shifts. U.S. Dept. of Commer., NOAA. 178 p.

NMFS. 2018. 2018 revision to: technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Office of Protected Resources Nat. Mar. Fish. Serv., Silver Spring, MD. 167 p.

NMFS. 2024. 2024 Update to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 3.0). Underwater thresholds for onset of permanent and temporary threshold shifts. NOAA Tech. Memo. NMFS-OPR-71. Available at https://www.fisheries.noaa.gov/s3/2024-10/Tech-Memo-Guidance-3.0-OCT2024-508-OPR1.pdf.

Sivle, L.D., P.H., Kvadsheim, and M.A. Ainslie. 2014. Potential for population-level disturbance by active sonar in herring. **ICES J. Mar. Sci.** 72:558-567.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. **Aquatic Mamm.** 45(4):411-522.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S.C. Webb, D.R. Bohenstiehl, T.J. Crone, and R.C. Holmes. 2009. Broadband calibration of R/V *Marcus G. Langseth* four-string seismic sources. **Geochem. Geophys. Geosyst.** 10:Q08011.

APPENDIX B: ENSONIFIED AREA CALCULATIONS

The ensonified area calculations are shown in Table B-1. They were based on representative seismic transect lines that could be surveyed on one day (totaling 222 km) and multiplied by the number of days with seismic operations (7 days).

TABLE B-1. Ensonified Area Calculations.

	Water Depth	Criterion	Daily Ensonified Area (km^2)	Total Survey Days	25% Increase	Total Ensonified Area (km^2)	Relevant Isopleth (m)
Marine Mammals							
	Deep >1000 m	160 dB	195.1	7	1.25	1706.9	438
Sea Turtles							
	Deep >1000 m	160 dB	34.7	7	1.25	303.9	78